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PLANT PROPAGATION

GREENHOUSE AND NURSERY PRACTICE

M. G. KAINS

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SLAT SHED IN FLORIDA NURSERY

Plants are all in pots plunged in soil to keep moist in summer and warm in winter.

PLANT PROPAGATION

Greenhouse and Nursery Practice

By

M. G. KAINS

Professor of Horticulture, Pennsylvania State College

NEW YORK
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PREFACE

WITHIN the last few years so many discoveries of new facts have been made by plant investigators, so many short-cuts and "wrinkles" worked out by plant propagators, and so many nursery, greenhouse and garden methods simplified or made more effective, that books hitherto available on plant propagation are now out of date. Nurserymen and other propagators who have not been able to keep their eyes upon the whole field have been calling for a book which will give them the best of these methods and "wrinkles" in the comparatively small compass of a single volume.

At the same time there has been a more and more insistent call for a volume that will not only include the character of information called for by nurserymen and other plant propagators, but also discuss the subject of plant propagation from the standpoint of fundamental principles and include the latest conclusions advanced by investigators throughout the world.

With these two main objects in view the author has brought together the latest information on all branches of practical and theoretical plant propagation so as to make a volume that will appeal with equal force to the professional propagator and to the teacher of plant propagation in agricultural colleges and schools at home and abroad. The former will be most attracted by the new methods and short cuts which will make for efficiency; the latter will appreciate the convenience of arrangement, the numerous illustrations and the large list of suggested practicums (page 292). To professional propagator, teacher and amateur the plant lists and condensed rules for propagation will also be specially interesting.

Literature of propagation is abundant, though much

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is necessarily repetitive. The best way to get in touch with the work done since 1888 is by means of the Experiment Station Record of the United States Department of Agriculture at Washington. This is a technical review of the world's scientific literature pertaining to agriculture. Two volumes, of six monthly numbers each, are issued annually at a subscription price of $1.00 a volume, with a restricted free distribution to libraries, government and state agricultural investigators, etc. It abstracts and indexes the current agricultural literature, not only of the United States Department of Agriculture and of the experiment stations, but the more important periodical and book publications of the world. Extensive and minutely detailed indexes are published semi-annually and assembled into combined indexes from time to time. By means of

NURSERY AND FLORIST INDUSTRIES OF THE UNITED STATES
(Figures from Census of 1910.)

	Year	Fls. & Plts.	Nursery Prods.
Acreage	1909 1899	18,248 9,307	80,618 59,492
Increase %		96.1	35.5
Value	1909 1899	$34,872,329 18,758,864	$21,050,822 10,123,873
Increase %		85.9	107.9
Acreage per establishment	1909 1899	$3,286 3,771	$2,132 2,028
Acre value	1909 1899	$1,911 2,015	$261 170

these indexes the searcher may easily post himself as to the scientific work reported on any agricultural subject in the least possible time. In the preparation of this

volume free use has been made of the Experiment Station Record, from which many passages have been copied, more or less condensed. Most of those relating to foreign and some concerning American work have been thus secured. The majority of these have been set in small type to avoid too frequent references in the text to the source of information. Where possible the original sources were sought and quotations or synopses made first hand.

The work of Lucien Daniel, so frequently presented in this volume, is likely to effect a revolution among traditional grafting doctrines, but this revolution will probably be slow in its movement because it must not be accepted without repeated investigation. Daniel's theories, though based upon facts, are naturally doubted by many plant propagators or are only partly credited. Yet in practice many of them have already been justified. Herr Lindemuth of the Royal University Garden at Berlin has supported some of them by his investigations and other investigators in Europe, Australia and America have thrown additional light upon the general subject of plant propagation. Considering the importance and the extent of the nursery and florist business, as shown by the last census of the United States, it is evident that competition between establishments will keep plant propagators on the qui vive to test new theories and practices and to adopt all those that will tend toward higher efficiency and economy of production. This fact is attested by the very generous response to requests for aid and suggestion made by nurserymen in many states. This aid the author gratefully acknowledges.

Special thanks are due Mr. B. F. Williamson of New York who drew almost all of the pen and ink sketches; to Mr. E. T. Kirk, photographer at the Pennsylvania State College for many of the photos not specially referred to below; to Mr. J. R. Bechtel of the horticultural department staff at the college for pictures taken in

the Henry A. Dreer greenhouses at Riverton, N. J.; to Mr. L. F. Reese and Mr. H. M. Hills, also members of the staff, for many helpful suggestions as to outdoor and indoor propagation respectively; to the A. T. de la Mare Company of New York for the set of pictures detailing hyacinth propagation; and to the United States Department of Agriculture and to experiment stations and propagating establishments which supplied the illustrations noted in the list of acknowledgments printed elsewhere.

The author has had too long an experience in writing and editing books and articles to suppose that this volume is perfect. He therefore earnestly requests that readers who note any least error of statement or typography will kindly notify him or the publishers so corrections may be made in subsequent editions. In the hope, however, that such errors are few and that the volume will meet a long-felt need the author confidently commends it to plant propagators and students of plant propagation.

M. G. KAINS.

State College, Pa., March 1, 1916.

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The following individuals, institutions and business houses have supplied the illustrations referred to by figures opposite their names.

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UNIV. OF CALIFORNIA

CHAPTER I

INTRODUCTION

1. Plant propagation is the multiplication or increase in number of plants in the perpetuation of the species. As applied by man, it includes knowledge of the proper time, place and manner in which best results may be secured. Fundamentally it is based upon (a) certain natural laws or principles which constitute the science, and (b) certain methods of manipulation which constitute the art of the processes as a whole.

2. Art and science contrasted.—Art is merely the knowledge of methods without reference to reasons whereby results may be secured. It therefore implies skill gained through practice. Science deals with the underlying reasons for certain forms of procedure, and the conditions which affect the process without considering the skill involved in manipulation.

To illustrate: A workman in a nursery (Fig. 110) may easily transplant 4,000 potted dahlia plants in a day of 10 hours without knowing anything specific of the underlying principles; whereas, the proprietor may know the principles and give proper orders for their application without being able to transplant half as many plants in the same time, yet he may be a master workman because of his knowledge of both the art and the science. The art is best acquired by following the example of a skilled workman; the science best from books and instructors.

3. Natural and artificial methods.—All methods employed by man are adaptations or improvements upon natural methods, instances of the application of which may be found in nature. For this reason they should hardly be called artificial, though they are often so termed.

4. Natural methods of propagation differ in the three general classes of plants. Annuals and biennials all propagate themselves by seeds, of which they usually produce an abundance. They are not propagated artificially

by any asexual methods; first, because the abundance of seed obviates the need of doing so, and, second, because few of them can be so propagated without difficulty.

Many warm climate plants used for ornamental bedding in gardens (coleus, geranium, achyranthes), though perennials in their native countries, are made to live as "stock plants" (145) from year to year in greenhouses though out of doors they are treated as annuals. They are, therefore, so propagated.

Perennials may or may not propagate by seeds. They may, therefore, be propagated by one or the other or both these methods according to convenience, economy or some other consideration. When they do not propagate

FIG. 1—MAKING CUTTINGS IN BIG COMMERCIAL GREENHOUSE
The man on the left is doing the "rough work"; the man on the right is "finishing."

by seeds, they do so by buds, of which they generally produce an abundance, either upon the branches and sometimes the leaves, or on roots or other underground parts. Thus, while the parent perennial plant may die, man (and sometimes the plant itself) may take advantage of either its seeds or its buds in perpetuation.

For instance, the underground stems of quack grass and bindweed are capable of producing a new plant from every joint, as every farmer and gardener knows to his sorrow. Again, should it be deemed necessary, the California big tree which at the estimated age of 5,000 years is steadily becoming extinct, thanks largely to human activity, might be given another 5,000-year start by propagating it from its buds by cuttings (Fig. 99). The process might again be repeated 50 centuries later and so on without a limit.

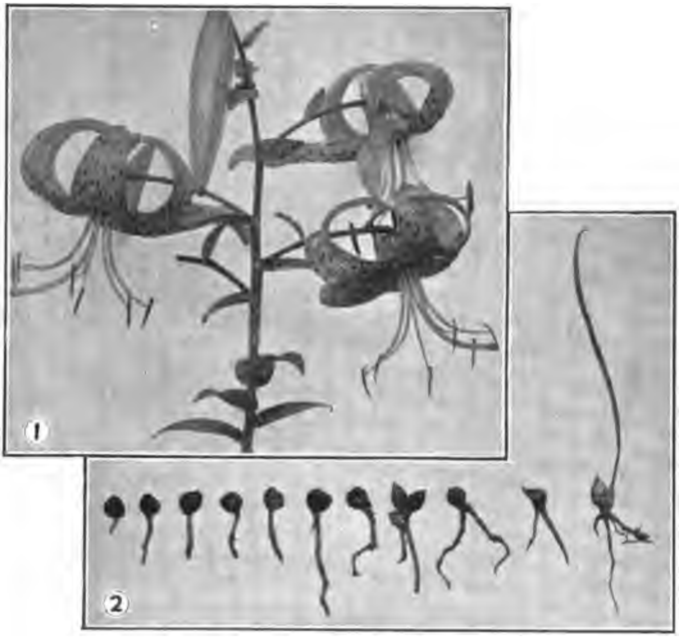

FIG. 2—TIGER LILY AND BULBLETS
1. Notice bulblets in leaf axiles. 2. Bulblets rooting a few days after falling off plants.

5. Life cycles of plants.—Every plant normally passes through a life cycle or history. The seed germinates or sprouts; the plant vegetates, blooms, bears seed and sooner or later dies. Life cycles vary in duration from a few days or weeks (peppergrass and portulaca) to many

centuries (big trees, giant redwood of California and certain species of oak and pine). Under normal (or natural) conditions, the duration of the life cycle of any species may vary considerably because perhaps of inherited vigor or environment or both.

For instance, in a sowing of garden carrots a few plants may "run to seed" the first season, though the general life cycle of this vegetable is two years; conversely, some annuals, as radish, may fail to seed the first year, but send up flower stalks the following season. Such cases are, however, exceptional.

So far as known, no plant lives indefinitely, though by the application of certain methods of propagation existence may be continued beyond the duration of the normal life cycle of the plant so treated.

For instance, the geranium, which is normally a warm climate plant, easily killed in cold climates by frost, may be propagated by means of cuttings, and thus not only its numbers increased indefinitely, but its life thus extended by asexual generation. In one sense this is not strictly extending the life cycle of the individual plant, for the original stem and roots are generally thrown away as having served their purpose.

Because all plants normally reach the limits of their life cycles, some method of propagation is necessary if they are to be perpetuated; otherwise they will be lost. To prevent this contingency among flowering plants, nature usually provides ample seed, though in some cases asexual methods have been developed. Strawberries propagate by means of runners (102); certain dogwoods by stolons (123); black raspberries by layers (96); houseleeks by rosettes (126); cannas by rhizomes (122); banyan trees by aerial roots from limbs; mangroves by their "knees" or prop roots; Irish potatoes by tubers (128); and so on.

6. The term environment is used to include all the external influences that, as a whole, affect a living organism in any way. Among the principal factors that make up environment are heat, light, moisture, and food supply.

7. Duration of life cycle determines the three general groups of plants; annuals, biennials and perennials.

a. *Annuals* complete their cycle in one season or less—oats, radish, cosmos, purslane.

b. *Biennials* require two growing seasons, or parts of two—hollyhock, turnip, mullein. The root lives through the winter of a cold climate or has a dormant period in a warm or arid one, and resumes activity when conditions again become favorable to growth. Before the second season of growth closes they mature their seeds and die.

c. *Perennials* live from year to year and produce seed

FIG. 3—PRICKING OUT PLANTS IN SHADED COLD FRAME

The men have to bend over to the level of their feet to place the plants in the soil in front of them.

or fail to do so. They are divided into three classes—herbaceous, woody, and shrubs and trees. a. Herbaceous perennials have perennial roots but annual tops—asparagus, peony, saccaline, bindweed. b. Woody perennials have perennial roots but biennial stems—the bramble fruits (raspberry, blackberry, dewberry). c. Shrubs and trees are woody in both root and stem, and persist from year to year without a definite loss.

8. Plant propagation methods, of which there are many, naturally divide themselves into two general classes dependent upon whether seed bodies (spores or seeds) or buds are used. Propagation by spores is so nearly akin to that by seeds that the two are usually classed under the one head—Seedage. Because propagation by means of seeds is dependent upon the previous action of the reproductive organs (pistils and stamens) it is called sexual; that by means of buds, in which no such action occurs, is termed asexual. This term is also extended to plant reproduction by true and adventitious buds.

FIG. 4—CRACKED SOIL

Bad physical condition due to lack of vegetable matter. Such soil dries out deeply because of the cracks.

9. Spores are asexual, usually one-celled, reproductive bodies of flowerless plants. A striking difference between them and seeds is that they contain no embryo. While reproduction of plants from spores is not dependent on sex, as in flowering plants, the process is, practically speaking, a sexual one. (Compare Seeds, 10.)

To illustrate, the black or brown spots (called sori) beneath the fronds of many ferns, produce hundreds or thousands of spores. These germinate on moist surfaces and produce small plant bodies (prothalia) each of which develop two distinct growths, an archegonium and an antheridium, which correspond respectively to the pistils and the stamens of flowering plants and are, therefore, the essential organs of reproduction in flowerless plants. When, during the process of growth, an antheridium unites with an archegonium, a sperm cell from the former fertilizes the egg cell in the latter and a little plant is produced—a fern, a moss, a mushroom, or some other flowerless plant, according to the species.

Spores are of interest to the horticulturist because they produce ferns, mosses, mushrooms, fire-fanging fungi (137), and many plant diseases such as apple scab, wheat rust, black knot of cherry and plum, downy mildew of grape, etc.

10. Seeds are fertilized ovules, structures which when mature include rudimentary plants (embryos) protected while dormant by seed coats and containing nutriment either in or around the cotyledons to supply the needs of growth. Since the production of seeds is due to the fertilization of ovules by pollen, the process is called sexual; hence the term sexual reproduction is often extended to include seedage. In beet, chard, and some

FIG. 5—WEEDING POTTED PLANTS IN COLD FRAME

other plants, the "seeds" are really the dried fruits or capsules which contain several to many seeds (p. 49).

11. Seeds vary greatly in size from that of the dust-like orchid and begonia to that of Seychelles cocoanuts, which sometimes weigh 40 pounds, and are 18 inches in girth.

12. The micropyle is a minute opening through the seed coats. Through it the pollen tube enters the ovule and the radicle emerges during the process of germination. Often it is almost invisible until the seeds begin to

germinate. In Lima bean it is seen close to the hilum.

13. The hilum of a seed is the scar left by the separation of the seed from the placenta of the ovary.

14. The embryo usually consists of three parts; cotyledons or seed leaves; plumule or rudimentary stem with its attached leaves between the cotyledons; and the caulicle or first internode or length between joints of the stem below the cotyledons and above the true root.

15. The number of cotyledons is used to divide plants into three classes: *Monocotyledonous,* or plants with only one cotyledon (asparagus, lily and grasses such as corn and bamboo); *dicotyledonous,* plants with two cotyledons (radish, marigold, dandelion); and *polycotyledonous,* plants with more than two cotyledons (pine, spruce.)

16. Farm and garden crops are almost all grown from seeds. Irish potatoes and sugar cane produce more or less seed, but this is not used except to develop new varieties. Jerusalem artichoke, sweet potato, tarragon and horseradish (17) no longer naturally produce seed, so must be propagated by asexual methods. Tree and small fruits do not come true to name or variety from seed; the seedlings are almost always inferior in some way or ways to varieties propagated asexually.

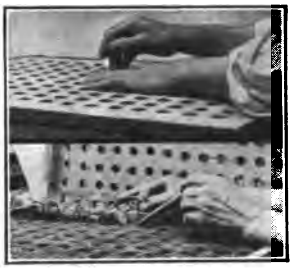

FIG. 6—SPOTTING BOARD

Above, making holes; below, dibbling-in seedlings.

17. Horseradish from seed.—A Hungarian experimenter has produced horseradish seed by ringing. Two types of plants were produced. Had their origin not been known they would hardly have been classed as the same species. Hence the author concludes that horseradish is only a hybrid and that the contrasting forms result from breaking this hybrid into its original types.

18. The essential organs of flowers are the pistils which contain the ovules or unfertilized and undeveloped "eggs," and the stamens which contain in their anthers

the pollen necessary to fertilize the ovules. Usually petals and sepals (non-essential organs) are associated with the essential organs, either for protection or to attract insects, humming birds and other creatures upon which fertilization of many plants depends. Some flowers, such as lizards-tail, are naked; that is, they have neither petals nor sepals, at least during the fertilizing period. Others, such as snowball and hydrangea and the ray flowers of many composites, often have neither pistils nor stamens. They are, therefore, called sterile.

19. The pistil consists of two essential parts, the stigma and the ovary. It may or may not have a style or stalk joining these two parts; or rather, when the style is very short it is said to be sessile.

20. Ovules are small growths on the interior walls of the ovaries. They usually consist of two layers, which inclose the embyro sac. This sac consists of several cells, one of which is the egg cell.

21. Fertilization of flowers is the rendering viable of ovules by the pollen. It is almost always between plants of the same species, and usually between flowers of different plant individuals. When plants of different species or genera unite by means of the pollen of one fertilizing the ovules of another, the resulting plants are called *hybrids*. Comparatively few tree fruits will hybridize, but several of the bush fruits and many ornamental plants have done so. Almost always hybrids of trees and shrubs must be propagated asexually.

Examples of hybridization are Kieffer, Le Conte and Garber pears, Rogers' grapes, wild goose plum, Wilson blackberry, Shaffer raspberry and many varieties of roses, cannas, begonias, gladioli, fuchsias, etc.

22. The fertilization process in flowers is essentially as follows: Ripe pollen is discharged from the anthers in the same or some other flower, generally of the same species. It reaches the "ripe" or receptive stigma of the pistil either through the agency of wind, insects or some

other way peculiar to the individual species of plant. The stigma being moist, sticky or hairy when receptive, holds the pollen grains until they germinate. In germination they extend growths downward through the style to the ovary, where they reach the ovules, which they enter through small openings called micropyles (one in each ovule). After entrance, the sperm cell contained in the pollen grain unites with the egg cell of the ovule, and the ovule, now said to be fertilized, develops into an embryo plant covered with the ovule wall, which develops into the seed coat of the ripened seed.

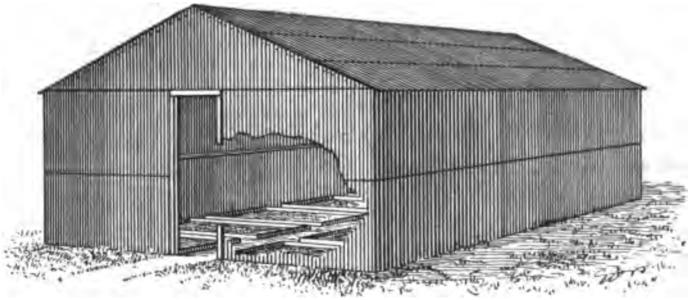

FIG. 7—LATH HOUSE FOR SUMMER PROPAGATION
This provides partial shade and helps retain moisture in the soil.

23. The ripened ovary with its seed is called the *pericarp* or seed case. It may be simple, as in pea and radish, or complex, as in plum and raspberry. Botanically speaking, the ripened ovary with, in some cases, other parts united to it, is called the fruit. Horticulturally speaking, a fruit is an edible pericarp. In some instances the edible part is the seed case (peach, cantaloupe); in others, the seed itself (corn, almond); again, it is mainly the swelled flower calyx (apple, pear); and yet again the swelled receptacle with the seeds (strawberry, blackberry).

24. Seeds contain plant food in the cotyledons or other parts to support the seedling plants during germination and until they are able to support themselves. Not until

the radicle has formed root hairs can plant food be taken from the soil (or other medium in which the seedlings are being grown); and not until the plumule has formed green leaves can such plant food be worked over to form

FIG. 8—GERMINATION IN CLOTH
The seeds are laid in rows on the cloth kept damp by sand in the tray below.

plant tissue. Until then the seedling lives on the food stored in the seed by the parent plant. This food includes starches or sugars, cellulose, fat, proteids or liquids or combinations of two or more of these materials.

Fully ripened dry seeds are highly resistant to outside influences; in some cases (squash, pine) continuing vital

or viable for many years (p. 49). It must be remarked, however, that the stories about the germination of seeds taken from ancient tombs, as from the pyramids of Egypt, are untrue. Among the seeds so delivered to the gullible is Indian corn, which, being an American plant, was not known to the ancient Egyptians!

25. Seed dissemination is accomplished naturally in three general ways—wind, water and animals.

Wind plays an important part in transporting very light seeds, especially such as are provided with appendages which buoy them up. Willow, poplar, thistle, dandelion, milkweed, sycamore and similar seeds are thus carried long distances. Wind also helps carry heavier seeds provided with wings that whirl or flutter in the air

FIG. 9—BRUSH SCREEN TO SHADE PLANTS OUT OF DOORS

Used mainly for slow-sprouting seeds and plants such as conifers.

and thus check descent more or less. Maple, elm, whitewood, box elder, basswood, ash and other winged seeds may be carried several hundred or thousand feet, depending upon the strength of the wind.

Water transports seeds that float readily much greater distances than it does those that sink. Among the best examples are apples, walnuts and acorns. Water also transports seeds that are carried by wind and by animals. It is, therefore, the most general agent of the three.

Animals carry seeds in one or the other of three ways: either, first, attached to their bodies (burs, beggar-lice, stick-tights, Spanish needles, etc.); or, second, in their intestines, where the juices of digestion fail to break down the protective coverings of the seeds (blackberry, cherry,

pokeweed, plum, etc.); or, third, by burying them for later use as food and then failing to dig them up. Squirrels are perhaps most active in this way: they bury immense numbers of nuts and acorns.

Man in his various activities is the greatest of all seed distributors. Consciously and purposely he collects seed in all parts of the world and transports it to places where

FIG. 10—PRICKING OUT SEEDLINGS IN FLAT
Note the "spotting" board for spacing the plants evenly.

it is to be planted; unconsciously he carries weed seeds in bedding and packing, on ships and trains. He may accidentally or purposely mix such seeds with valuable ones and thus introduce them where the shipments are distributed. The progress of the race westward from India, Assyria, Palestine, Egypt, the Mediterranean and Northern Europe to America and Australasia may thus be traced by weeds and cultivated plants carried by man.

26. Seed transportation is conducted upon an extensive scale by scores of wholesale and retail seed merchants in

all parts of the world. The rules herein presented (29), especially those concerning moisture and heat, are followed with great care. Seeds such as acorns are very difficult to transport long distances. Usually thick-coated and bony seeds require moist, confined air; thin-shelled ones, dry conditions. For shipping to or through the tropics seeds are usually sealed in tin cases or oiled packages. Most seeds, however, sent through ordinary cool climates, after being thoroughly air dried, need be placed only in cotton sacks, large paper packages or manila envelopes. Apple, pear and other small seeds are often mixed with powdered charcoal.

Often more satisfactory results may be secured by growing the seedlings of species very difficult to ship in the seed form and shipping these either actively growing in wardian cases or dormant as nursery stock. The former method is not much practiced; the latter is the favorite method of nurserymen.

27. The rest period of seeds is that interval between the apparent maturity of the seeds upon the parent plant and the time when the seeds will germinate under conditions normal to the species. Such seeds apparently cannot be made to sprout earlier. A majority of garden seeds will sprout within a month of the time they mature; a few almost without any delay. It is no uncommon thing for seeds of cereals to sprout while still in the head, should the weather be wet for a considerable time at harvest. The mangrove normally sprouts its seeds while still attached to the parent plant. The rest period is really a time of chemical change or ripening of the foods stored in the seeds. It may be broken by drying, freezing, chemicals, or by freezing and thawing.

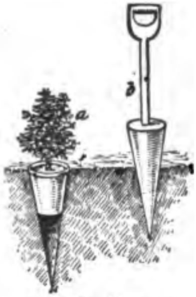

FIG. 11—POT PLUNGING
a, pot in soil. b, dibble.

Howard and Whitten of Missouri planted about 200 species of seeds representing 51 genera to determine whether seeds in general are capable of germinating immediately after ripening if placed in favorable conditions. Seeds of grass, lily, pink, mallow, legume and composite families seem to have no rest period, while rose, cashew and vine families have a pronounced one. In general seeds of woody plants have a more pronounced rest period and are more difficult to force into growth than seeds of vegetable and other her-

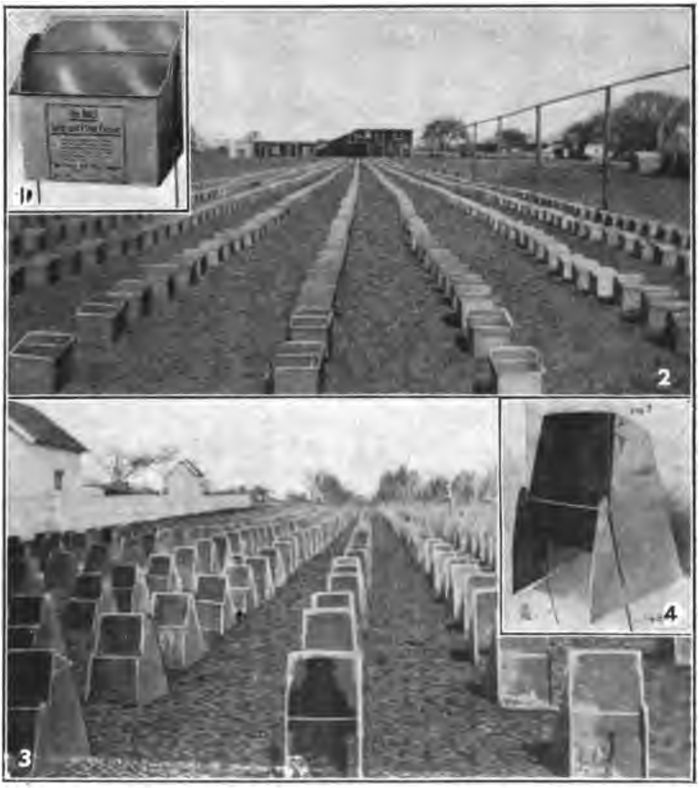

FIG. 12—TWO STYLES OF PLANT PROTECTORS OR "FORCERS"

1, closed paper-sided protector with glass top. 2 and 3, forcers in field use. 4, open-sided protector with adjustable glass front which allows of ventilation.

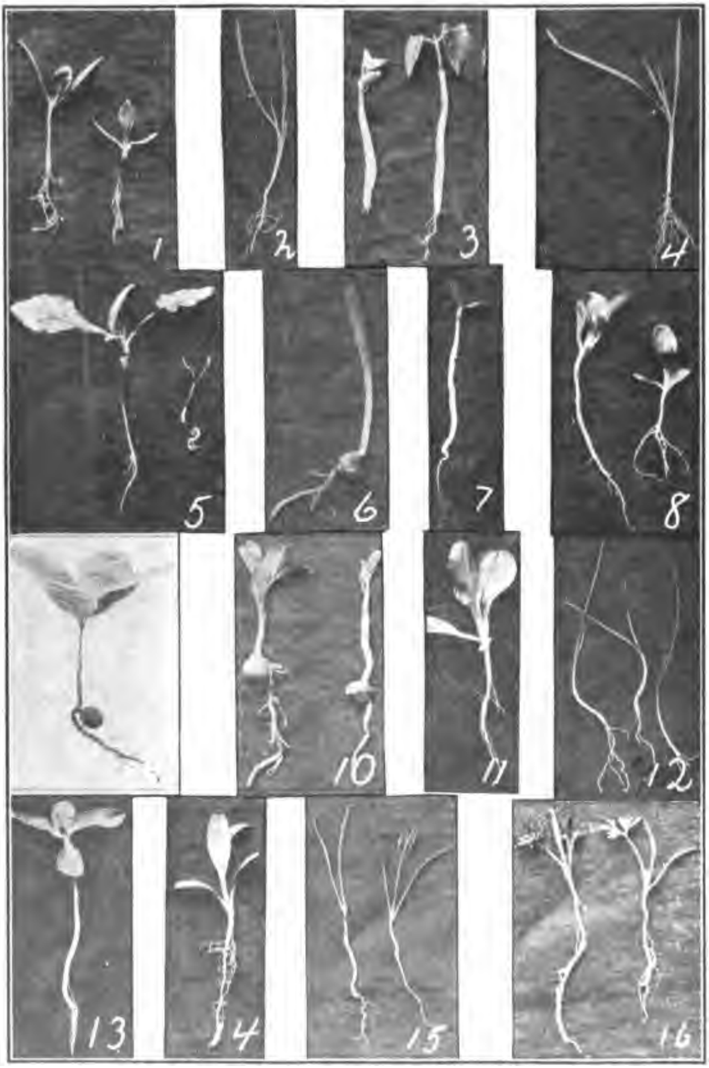

FIG. 13—CHARACTERISTIC FORMS OF SEEDLINGS

Top, left to right: Spinach, salsify, bean, salsify. Second row: Beet, corn sunflower, lettuce. Third row: White oak, garden pea, lettuce, onion. Bottom row: Sunflower, cardoon, fennel, carrot.

baceous plants. Variation in length and intensity of the rest period is greater between species than within species. Etherization tends to stimulate seeds into early growth and to increase the percentage of total germination. Soaked and stratified seeds are more strongly affected by ether than are dry seeds. A 12-hour exposure to ether seems the most favorable dose to force seeds to germinate.

28. Handling fleshy fruit seeds.—Seeds of many fruits must be freed from their fleshy or pulpy coverings before they can be stored or planted. When there is no danger of injury to them the fruits may be crushed or ground. For instance, apples are so treated, the pomace mixed with water and allowed to stand until the pulp has partially fermented. The process requires a week to two or three, depending mainly upon the temperature and the character of the pulp. The seeds become separated from the pulp and sink to the bottom. An occasional vigorous stirring aids the process of separation. The pulp is finally poured off, the seeds collected, re-washed and dried.

Soft fruits, such as blueberries, raspberries, strawberries, and cranberries, are often treated in this way, though they are perhaps as often handled like tomatoes, cucumbers, melons and other fruits, merely crushed under water and then washed, the pulp being skimmed off and the seeds allowed to settle.

Sometimes the separation requires chemical treatment to get rid of unnecessary membranes. For instance, the membranes of persimmon seeds may be easily removed after a soaking in weak caustic potash solution (a stick to a pailful of water).

Fresh ashes, lime and lye are of great help in freeing many seeds of their resinous coverings.

29. Points to remember about seeds.—In Bulletin 58 of the Bureau of Plant Industry, J. W. F. Duvel writes in substance as follows, except where brackets are used:

A. Seeds are living organisms and must be properly treated to get good results when sown. [They are dormant creatures. Or to use an analogy, they are combined physical and chemical laboratories which need only the proper conditions of moisture, heat and oxygen to get them in operation.]

B. The most important factors that determine vitality are maturity, harvest weather conditions and ways of harvesting and curing.

C. Immature seeds soon after ripening usually sprout well, but if stored lose vitality rapidly; well-matured seeds harvested under favorable conditions should keep long.

D. Seeds harvested in damp weather have less vitality than those harvested in dry weather.

E. Seeds once injured never regain full vigor.

F. While proper curing is of the utmost importance, great care is needed to prevent heating, since this reduces vitality.

FIG. 14—SEED AND BULB DRYING SHED

Temporary poles and racks are placed on the permanent poles

G. The life of seed varies with the family, genera and species; but there is no relation between the longevity of plants and the viable period of the seed they produce. Some seeds lose their vitality in a few weeks or months [California poppy], others live for years [melons, cucumbers].

H. With special precautions the life of seeds may be lengthened within reasonable limits.

I. Certain seeds retain their vitality better in some sections than in others; i. e., climate plays an important part.

J. Moisture is the chief factor in determining the longevity of seeds under commercial conditions.

K. The bad effects of moisture are heightened where the temperature is high. Often vitality is destroyed in a few weeks or

months when seeds are stored in a moist, warm climate; but where the storage is dry, normal temperature ranges are not so important.

L. The majority of carefully dried seeds can stand long exposure to a temperature of 98, but 102 to 104 for a similar time will kill them. In a moist air 86 will soon cause injury.

M. Seeds to be sent to a moist climate should be shipped in air-tight packages, but they must be dry before being sealed.

N. Seeds under ordinary storage conditions respire most freely when moisture is present, but respiration is not necessary to their life, because they may be successfully kept even better for a time under conditions unfavorable to respiration.

CHAPTER II

GERMINATION

30. Germination, botanically speaking, is the resumption of growth by the dormant embryo or young plant in the seed. Popularly it is the sprouting of seeds, the first step in vegetation. To enable the seed to germinate it must have a perfectly developed embryo, and be mature or nearly so. It must not be too old for its species (p. 49). It is complete when growth has ruptured the seed coats and the embryo has emerged.

31. How seedlings grow.—Seedlings push through the soil by the extension of their radicles or hypocotyls, aided in some cases by their cotyledons. When the descending parts have taken hold of the soil by means of their root hairs, or by lateral root growth, upward growth begins. Though in some cases (pea, oak, Fig. 13) the cotyledons descend, or at least remain beneath the surface to help anchor the seedlings, they usually "come up" above the surface (bean, radish), and often turn green and perform the functions of true leaves (maple, tomato, nasturtium). In the former case the cotyledons contain large quantities of food which nourish the plantlets; in the latter the role of nurse is dropped as soon as they turn green. Often while the first true leaves are expanding, the roots contract and extend laterally, thus drawing the little plants deeper in the soil and anchoring them firmly.

32. Growth in length is due to cell division and development at the growing point; that of girth, by cell division and development of the cambium and contiguous cells.

33. Hypocotyl or caulicle, the first internode or part of stem below the cotyledons and above the radicle or beginning of the true root.

34. Radicle, that part of the embryo below the cotyledons, including the caulicle and the nascent root; by some botanists restricted to the extreme point of the caulicle from which the root develops.

35. Factors of germination.—Germination depends upon four factors: viability, water, free oxygen and

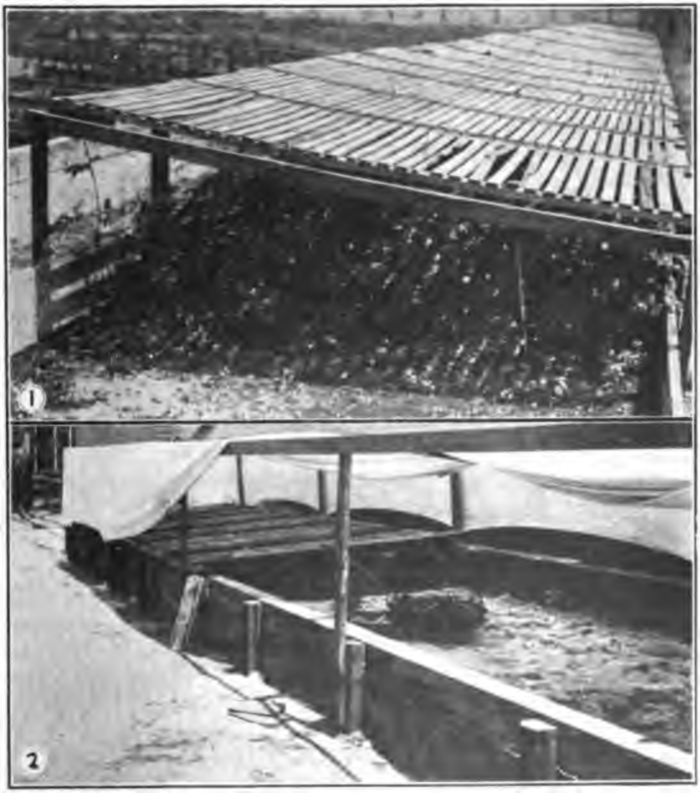

FIG. 15—SHADES FOR OUTDOOR PROPAGATING BEDS

1. Lath shade. 2. Cloth on frame. The shades may be lifted in dull weather to accustom the plants to the sun.

proper heat. The seed of each species, and even some varieties of a single species of plant, seem to demand different degrees or quantities of one or more of these factors to produce best results. The most favorable combination of these factors for each kind of seed is, therefore, called the *optimum* for that species. Age and stage of maturity of the seeds exercise more or less influence upon germination. Presupposing viability, which means ability to live, the steps or stages of germination are: 1. Absorption of moisture by the seed. 2. Conversion of stored food under favorable temperature into sugars by enzymes or natural ferments. 3. Stimulation of the embryo cells into growth. 4. Bursting the seed coat by the swelled embryo, etc.

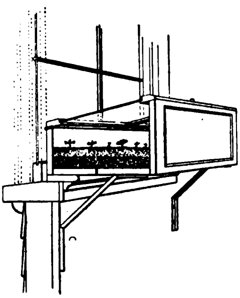

FIG. 16—CUTTING FRAME FOR WINDOW
A handy device for schoolrooms.

36. Water is necessary in germination because plant food must be in solution to be of service to the embryo. It is, perhaps, more important than oxygen and heat because too much or too little may prevent germination. Therefore, in practice, it requires careful regulation. Generally it reaches the seed through the soil, though many seeds and spores sprout on any surface moist enough, or any material which will supply their needs.

In nature there are many variations. Cocoanuts will sprout among rocks where thrown up by the sea, their roots sustained by the "milk" while searching perhaps several yards for crevices in which to secure a hold and food. Countless kinds of seeds blown by wind or carried by water sprout among mountain rocks where both soil and water are in very small supply. Spanish moss seeds germinate on the limbs of trees. Mistletoe does this also, but the sprouts take parasitic root in the tissues of the tree to which they attach themselves.

Still water retards germination. In the case of buckwheat grown experimentally, most seeds sprouted in 24 hours in running water, but those in still water took two days or more.

37. Temperature variations influence seeds in germination less than do those of moisture. Both, however, should be avoided. Seeds will stand much heat and cold if dry, but if wet, frost may injure them and heat may "cook" them. In seed storage, everything promotive of decay must be avoided. Especially must the seed be kept

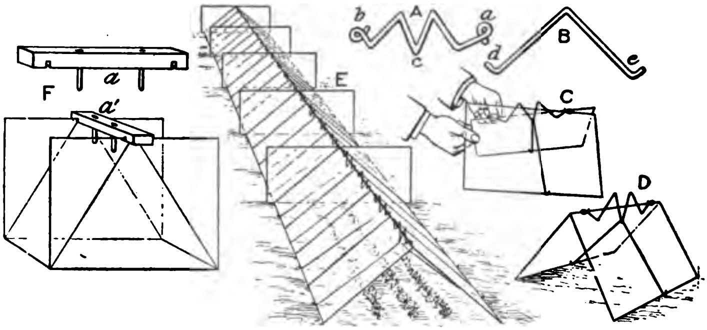

FIG. 17—GLASS PROTECTORS FOR OUTDOOR PLANTING

At left, F, panes of glass fitted together by wooden top. At right, continuous plant forcer: A, wire for ridge; a, b, outside; c, inside; B. wire to hold side panes at d and e; C, making section; D, completed section; E, continuous row.

as dry as possible. The room may be even hot, provided it is not damp. This rule applies to small as well as large quantities of seeds. Often corn, wheat and other cereals improperly dried before shipment heat in transit and are ruined both for seedage and food. Sometimes the heat is great enough to cause great losses in warehouses and ships, in some cases even starting fires by spontaneous combustion.

38. Time of sowing out of doors, as well as depth, influences temperature. Seeds planted deeply in spring may rot because they are too cold; and those planted shallow in summer may continue dry and thus fail to sprout. Hence early spring sowing of any kind of seed should be shallower than that of the same kind in late spring or summer. No general rule can be given, be-

cause each species has its own preferences; but large seeds may be sown two to four times their diameters and small ones only slightly covered—just enough to hide them from the light. Fresh and strong seeds may be sown deeper than old or weak ones, because the seedlings should reach the surface with less difficulty.

FIG. 18—PROPAGATING BENCH SHADED WITH NEWSPAPERS
Notice the burlap curtains beneath the bench. These give several degrees of bottom heat when lowered.

39. Light hinders some seeds from sprouting (poppy, adonis, larkspur), but has no apparent effect upon others. Its influence upon germination is not fully understood. Seeds of mistletoe, Spanish moss and many orchids germinate as well in light as in dark places, perhaps even better.

For these reasons it is considered advisable to shade fine seeds and spores while germinating. Nothing is to be gained by the reverse process. When covered with soil they are usually shaded enough, but when sown upon or very near the surface they sprout better when shaded at least partially. Parsley, thyme, marjoram and other slow-sprouting and small seeds do best

in the open under shade. This is, however, more because of controlled moisture than of light. Paper and muslin are popularly used for shading. (Figs. 15, 18.) When the plantlets have two or more true leaves the shade may be removed.

40. Influence of sunlight on seed germination.—Experiments in Germany show that in nearly every instance seeds subjected to direct rays of the sun were retarded in germination, although the effect on the total germinative ability was not influenced in any appreciable degree, the total number of germinations in each lot being practically the same. One lot was germinated wholly in the dark, another received sunlight 44 days, while the control lot was germinated out of the direct rays of the sun.

41. Seedlings grown without light.—A. Bergerstein, a German investigator, grew seedlings of more than 100 species of gymnosperms to determine the effects of light and darkness on them. His general conclusions are that except *Ginkgo* and *Ephedra* the seedlings become green even in the dark. The rapidity of coloration varies with the temperature. *Cycas* and *Zamia*, even under favorable temperatures, failed to develop chlorophyll in the total absence of light. Among many conifers, chlorophyll is formed in the dark, both in the cotyledons and the hypocotyl (except in *Larix*). *Araucaria* produced it in branches developed while in the dark several weeks. In *Abies* and *Cedrus* the embryo, even in dormant seeds, contains chlorophyll. In other species the seedlings begin to turn green before the seed coat is broken or shortly after the emergence of the radicle. Conifer seedlings in the dark have shorter roots and cotyledons, but larger and thicker hypocotyls than similar plants grown in the light.

42. Oxygen is usually in ample supply for germination. It is always present in soils neither tightly inclosed nor water soaked. Water plants (lotus, water lily) have special ability to germinate under water.

43. Depth to plant.—Deep planting is unfavorable to germination, first, because the supply of oxygen is restricted and, second, because the seedlings may be unable to reach the surface, especially if the soil is hard. Under glass the same species of seeds may be planted at twice the depth employed in the open. After planting, the soil should be firmed lightly (Fig. 20) to avoid washing when watering. If the soil is hard and likely to bake, apply a light mulch of old compost in the rows.

44. Very small seeds (begonia, thyme) are merely dusted on the soil in a seed "pan" which is sunk in moist sand or moss, water never being applied directly. (Fig. 95.) Sometimes the reverse method is practiced—the water being contained in an interior pot In each case the water seeps through the porous pot and keeps the soil moist.

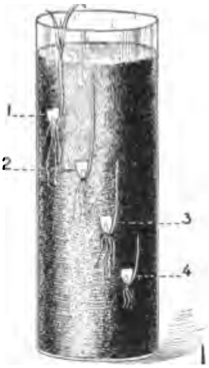

FIG. 19—DEEP PLANTING EFFECTS

Seeds planted all at one time.

Seeds the size of celery are often watered after sowing by standing the pans in shallow water until the surface soil becomes moist. By these methods the watering is quickly done without danger of washing the seeds out of the soil. Too much water is as bad as too little, because the soil becomes water-logged and the seeds decay. Dampness throughout the whole soil is all that is needed in a seed bed, except for aquatic plants (water lily, rice). A wet surface over a dry soil is very bad because the roots cannot grow properly. Hence seeds and seedlings should be watered from below whenever possible.

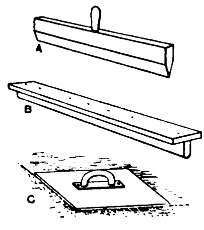

FIG. 20

A and B, row markers; C, firming board

For large numbers of seeds and for big seed beds, watering with a hose (or sprinkler) is necessary. Never should a strong stream or an open hose be used for such work, because these may either wash out or bury the seeds, pack the soil or do all three. Florists and gardeners who grow many plants under glass use great care in watering seeds. They aim to keep the soil moist, not wet, and never logged, because

excess moisture tends to weakening and damping-off (78) of seedlings.

45. Aids to germination.—Most seeds properly handled germinate freely; but seeds of certain families, the Umbelliferæ especially, are slow (parsley, carrot, celery, parsnip, etc.). These and hard, bony seeds (48) allowed to dry out too much may fail entirely unless treated prior to sowing. Their treatment seeks to soften or break the seed coats so the embryos may emerge.

46. Enzymes used experimentally in some cases increased the percentage of germination when the seeds were soaked several hours in a solution of some active enzyme or enzymes; the vigor of the young plantlets was often enhanced at the same time; within limits these good effects increase with the strength of the solution; diastase seems to be the most useful; tomato seeds seem to respond especially well to diastase.

47. Chemicals, usually dilute, or weak acids or alkalies, are sometimes used for seeds with hard, bony coats affected neither by soaking nor freezing. They soften the shells so water may enter. Vinegar aids the seeds of bramble fruits (blackberry, raspberry, etc.). Sulphuric acid (commercial strength) is sometimes used for cotton, alfalfa and clover seeds, the soaking lasting two or three to 20 minutes (Fig. 21). Thorough washing with water after the soaking is essential. Great care must be exercised in diluting the acid. The acid may be poured slowly into the full volume of water, but the reverse order must not be followed because the acid will "fly." The acid must not touch the skin or fabrics, because it burns.

FIG. 21—KENTUCKY COFFEE TREE SEEDLING

Sulphuric acid made this development in 40 days.

The acid method is found in nature; for seeds of many fruits are softened by the acids of the fruits themselves or by those in the stomachs and intestines of birds and animals that eat the fruits (barberry, cedar, cherry, mulberry, thorn, etc.).

48. Mechanical helps are used for seeds whose coats are too hard to be affected by any of the methods so far described. Filing or boring holes in Abyssinian banana,

FIG. 22—STUDENTS AT PENNSYLVANIA STATE COLLEGE

1. Setting cabbage plants. 2. Student vegetable gardens. Dairy barn in rear. Each student does his quota of work in the field. From 125 to 150 plan and tend their gardens each spring semester.

moonflower, canna and wild cucumber is often done. The object is to let water in to the cotyledons. Lotus seeds not kept in water from time of ripening have also to be treated thus; but if kept immersed as in nature, they will sprout readily under favorable conditions.

49. Stratification is a modification of nature's method of handling hard-shelled seeds. In cold climates the seeds are broken open by frost; in warm ones by the moisture usually abundant during the so-called winter

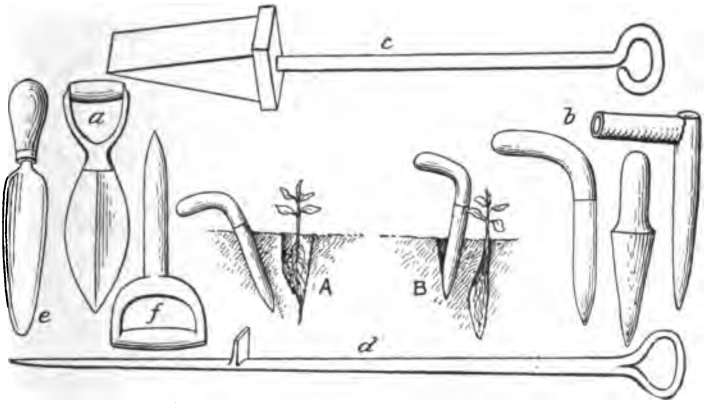

FIG. 23—DIBBLES, THEIR USE AND ABUSE

a, flat-bladed, wide style; b, homemade "punch" dibbles; c, pot-plunging dibble; d, root-graft planting dibble; e, trowel style; f, dibble made from spade handle. A, right way to use dibble, when pressing soil from bottom of hole to top. B, wrong way—pressing soil from top and leaving air space around roots.

or rainy season. Stratification consists in fully exposing the seeds to the action of the weather. The common practice is to place the seeds in shallow boxes in thin layers alternated with layers of sand or sifted soil. These boxes, covered with galvanized hardware cloth (one-half inch mesh) to keep out squirrels, mice and other creatures, are then placed flat on the ground out of doors so they will be moistened by rain and snow and will freeze and thaw as frequently as possible. The same method

is practiced in warm climates where moisture in effect takes the place of frost.

This process of stratification depends for its utility upon the osmotic passage of water into the seeds which are thereby softened so the embryo can easily emerge. In cold climates frost splits hard-shelled seeds, which in nature are kept moist by the pulp around them (peach, walnut) or by fallen leaves which cover them (hickory, chestnut). Many hard-shelled seeds have a seam through which water enters. Perhaps the majority of such seeds, if placed in the soil and kept there through the winter, would be sufficiently soft by spring, even without frost action, to germinate readily.

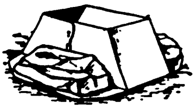
FIG. 24—PAPER PLANT PROTECTOR

50. Stratification to maintain moisture in seeds (apple, cherry) is often practiced even in cold climates. If such seeds were allowed to dry out they would be useless. Hence, as soon as gathered they are stratified, often 12 to 18 inches deep, so they will not sprout but will keep moist until the autumn, when they are dug up and stratified in the usual way. (Compare 54.)

51. Nurserymen's stratification method.—Nurserymen often stratify peach and plum seeds in shallow, bowl-like pits or in trenches which hold many bushels.These are covered with sand and protected as already described till spring. The seeds are then sown after the sprout has made a little growth. This method is better than sowing the seeds in the nursery rows during the fall, because the seeds can be better protected from animals and also because soil prepared in spring is less likely to bake than that prepared in the fall.

52. When to plant stratified seeds.—Stratified seeds should always be planted early in spring before germination starts, because many species sprout while the ground is still cold (pear, beech, oak, apple). If sprouting starts

before sowing, the percentage of loss will be high. Hence the seed bed should be prepared the previous fall so as to lose no time in spring. Peach and plum seeds do not suffer as much as do apple and pear seeds. Should it ever be necessary to sow the seeds, especially of small kinds, such as apple, strawberry, raspberry, while the soil is wet and cold, it is a good plan to open furrows and cover the seeds with well-decayed, fibrous compost, sawdust or similar material, so as to prevent baking. A good mixture for this purpose is rotted sod, sharp sand and cow manure which has been rotted a year or more and turned over twice or oftener to secure uniformity.

53. Necessity of freezing.—Whether freezing is necessary to cold climate seed germination is not decided. It does not, however, injure the seed germs but often helps in removing natural obstructions such as hard shells. Hence, it is preferred to cracking by hand, necessarily a slow and risky process.

FIG. 25—VIEW IN FLORIDA NURSERY

Shifting palms, a very important process in plant growing.

54. Soaking of seed is often employed as a substitute for stratification, the dry seed (locust, apple) being covered with water from half a day to two or three days before sowing. This is of special use in cases where the seeds have become unusually dry. Many nurseries now store their peach pits dry from harvest time through the winter until within two weeks of planting time, when the seeds are placed in barrels of water. Since imported

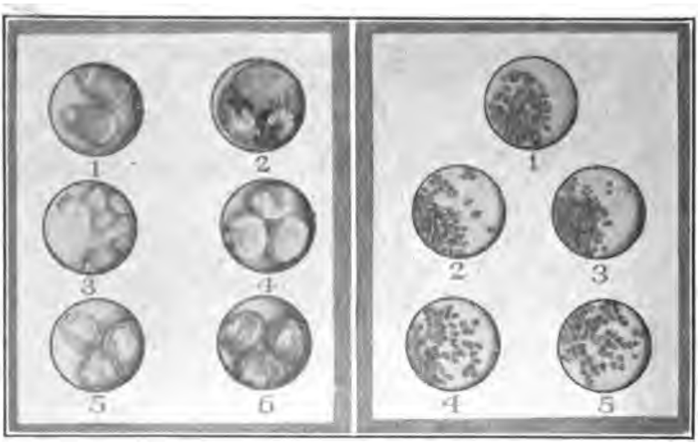

FIG. 26—SEED STUDY CARDS

In each circle punched in cardboard seeds are placed; at left, corn of various kinds; at right, clovers. The cards are then covered with glass and fastened together with adhesive tape or passepartout.

apple seeds do not reach the United States before midwinter, they are generally soaked two or three days, and then placed in stout cotton bags between cakes of ice and kept thus until planting time arrives. Due to the impracticability and uncertainty of the latter process, many nurserymen in this country prefer to buy dormant apple, cherry and other seedling trees from abroad (159). These are planted in nursery rows and later budded to the desired varieties.

55. Soaking of farm and garden seeds (peas, beans, celery, corn) is common, but good results are less common than is popularly supposed, for the soil should be decidedly moist and the soaking discontinued as soon as the seeds have swelled. When kept in water longer, and when placed in soil too wet, decay is almost sure to occur; and if placed in soil that is too dry they may dry out and fail to grow in consequence. With strong seeds sown out of doors in cold or unfavorable soil half a day to a day may shorten the time the seeds would be under such conditions and thus be a help.

56. Soaking beet seed experimentally shortened the time of germination; soaked seed germinated in four, five and six days after sowing, while dry seed required two weeks. Soaking the seed was done for 12 to 14 days at a temperature of 43 to 48 in 35 to 40 pounds water to 40 pounds seed. All seeds must be equally dampened but not wet and must be frequently stirred.

57. Scalding is often done to very dry and hard-shelled seeds which are little, if at all, affected by cold water or by freezing. For instance, the seeds of the Kentucky coffee tree are covered with boiling water, which cools rapidly enough to prevent injury. The seeds of the nearly related honey locust are usually soaked in very warm water for two or three days before planting. In nature only a small proportion of these seeds sprout. The reason that even these sprout is probably that the seed coats are softened by the fermentation of the pulp around them in the seed pod. The acid treatment, probably, will give quicker and better results (Fig. 21).

Scalding does not mean boiling; merely pouring boiling water over the seeds and letting it cool gradually. Such seeds, even in nature, mostly fail to germinate unless some such action as fermentation occurs.

58. Hot water used by Wernicke, a German investigator, in germination experiments with *Acacia molissima* and *Lathyrus* gave 60 per cent when soaked six hours at 122 degrees, 72 per cent when soaked three hours at 167 degrees and 92 per cent when heated from 204 to 212 degrees for an hour. Untreated seed handled in flower pots of sand the same as the treated seed gave 50 per cent.

59. Vitality of seeds.—Most seeds contain more or less specimens that will not germinate at all. They are not viable; in other words, they are dead even though freshly gathered and properly handled. Among viable seeds vitality varies greatly, but unless the germs be vigorous they will not sprout well nor produce vigorous plants. Hence the importance of buying the best. Since the price paid for good seed is very little compared with the value of the crop, the best farmers never haggle over the "high prices" of seeds sold by reputable seedsmen (77).

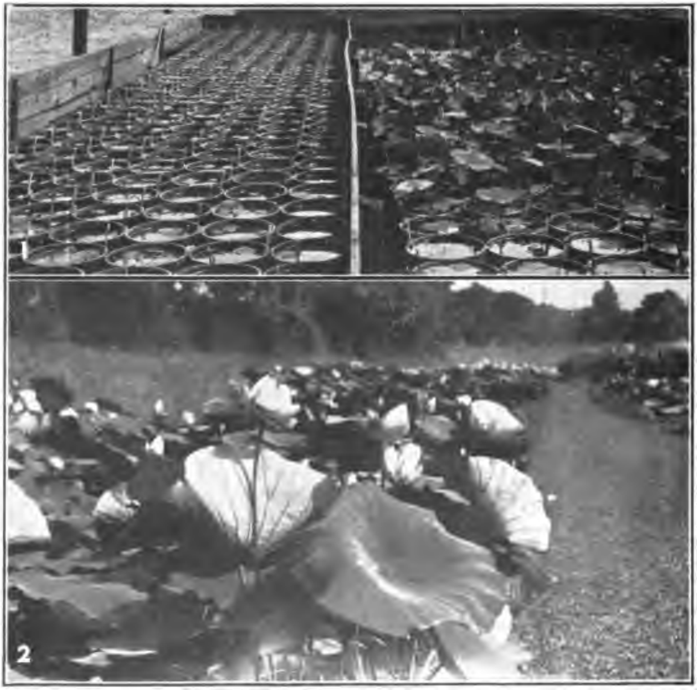

FIG. 27—NELUMBIUM (LOTUS) PROPAGATION

1. Seedlings in pots kept very wet. 2. Outdoor bed in pond. Seeds of most water plants must be kept moist from the time they ripen until they have sprouted.

For instance, the Long Island cauliflower growers never pay less than 75 cents an ounce for seed, all of which is purchased in large lots on contract by their co-operative association. The lowest retail price quoted by a well-known seed house is 60 cents an ounce for an old standard variety; the highest, $7.00, but this is for a new variety.

Among farm crops that suffer because of low vitality seeds are clover, blue grass, corn and wheat; among garden crops, cabbage, cauliflower, onion, turnip, parsnip, lima bean, celery. Hence their high price.

60. Seed in the tropics.—Many kinds of seed deteriorate rapidly in tropical climates; instances of 90 per cent germination immediately on gathering with only 50 per cent a month later and zero at three months. Lettuce is said to lose vitality in a few weeks.

61. The principal influences that affect vitality of seed are kind of seed, climate, maturity, age and method of storage.

62. Age of trees seems to influence seed vitality; fir trees about 150 years produced highest vitality seed by French experimental tests.

Powdered charcoal is recommended as packing for such seeds as lose their vitality when shipped long distances.

63. Acorn and nut vitality.—Many nuts and acorns quickly lose their vitality when dried; therefore, they should be either planted soon after maturing or stratified in moist but not wet sand, soil or moss and kept in a cool place. Dr. T. H. Hoskins reports perfect germination of butternuts stored in a loft four or five years!

The longevity of seeds is well illustrated by the following instance. At Columbia, Mo., white clover seed which had been buried about six feet deep under a race track for 35 years, was found, upon being uncovered, to germinate freely.

CHAPTER III

GERMINATION AND LONGEVITY OF SEEDS

64. Size of seed generally produces proportionate seedlings, not only as to species but as to specimen. A mere glance at a lima bean would suggest that the seedling would be many times larger than a begonia seedling. The same generally holds true of the larger, heavier specimens as compared with the smaller, lighter ones of the same species.

Galloway found that large radish seed germinates more quickly and certainly, and produces marketable plants sooner and more uniformly than small seed, while small seed gives proportionately larger plants than does large seed, though not to an extent believed to be advantageous in practice. Another investigator found that pea plants from large seed bloomed four days earlier than those from small, and produced marketable peas four days earlier and the main crop five to six days earlier. Beans acted similarly.

65. Large seed in plant production.—M. B. Cummings of Vermont reports a series of experiments with seeds of sweet peas, sweet pumpkins, Hubbard squash, lettuce, beans, parsley, radishes, spinach, garden peas and other plants to determine the relative value of large and small seeds on plant production. The experiments, as a whole, show a distinct advantage in using large and heavy seed. Sweet peas gave earlier bloom, a larger number of blossoms, and a larger number of blossoms of good quality. The plants were also heavier and more prolific and thrifty. Small squash and pumpkin seed gave a larger number and greater total weight of fruit, but were markedly inferior as to number and weight of ripe fruit. Large lettuce seed produced larger seedlings, an increased weight of edibly matured plants with better heading capability, earliness and uniformity. Of the crops tested, garden peas alone showed little or no difference when the seed was harvested as green peas. There was a slight gain for plants from large seed allowed to mature. Large bean seed gave an earlier product, but was slower in germinating.

66. Delayed germination.—When conditions are normal, many seeds will sprout in less than three days (mustard family); others seem to require three or more weeks (parsley family); still others do not germinate for a

year or more (holly, thorn, mountain ash). These differences may be due to the form of the stored food, the character of the seed coats, the nature of the plant, the dryness of the seeds or of the soil, etc. For instance, ginseng seeds, if sown as soon as ripe, should sprout the following spring; if dry they may take 18 months or

FIG. 28—VEGETABLE PLANT BEDS

1. Celery for transplanting. 2. Seedling lettuce plants. The plants are kept free from weeds and are thinned and transplanted as may be needed.

more. Clover and alfalfa "hard seeds" are slow unless treated with sulphuric acid as already indicated (47).

67. Delayed germination, according to W. Crocker, an English investigator, is due to the structure of the seed coats rather than to that of the embryos, as popularly believed. Those coats which exclude water are slower than those which exclude oxygen. In nature, growth of delayed seeds results from decay of the seed coats by longer or shorter exposure to germinative conditions.

In garden practice, advantage is often taken of difference in time of sprouting by sowing quick-germinating and slow-sprouting seeds in the same rows, the former to act as markers of the positions of the rows so cultivation may start at the earliest possible moment. The markers must always be sown very thinly. Radish is a favorite for this purpose, because it sprouts and matures early.

FIG. 29—CALIFORNIA PRIVET IN OHIO NURSERY

This ornamental is one of the leading hedge plants today.

68. Re-germination of seeds.—Popular opinion is wrong in the belief that seeds once dried after germination are useless for sowing or are necessarily killed. Certainly they are not quite as good, but they may sprout again fully as well as the first time and produce just as good plants. Nowoczek made re-germination tests under temperatures varying between 60 and 68 degrees with results

that show that corn, rape, flax, peas, buckwheat, onion, radish and some other seeds will re-germinate several times. Therefore, should drouth follow sprouting, it will not necessarily indicate that the sprouted but dried seeds of these crops will fail to germinate again under favorable conditions.

RE-GERMINATION TESTS

Kind of Seed	Number of Times and Percentage of Germination						
	1st time	2d	3d	4th	5th	6th	7th
Wheat	70%	70%	57%	31%	25%	10%	1%
Barley	85	78	74	40	33	17	4
Oats	90	83	77	62	40	27	8
Corn	98	96	66	14	3	—	-
Rape	95	55	27	17	1	—	-
Flax	88	78	30	9	—	—	-
Red Clover	85	41	10	3	—	—	-
Peas	87	38	3	—	—	—	-

FIG. 30—WRINKLES IN GROWING PLANTS IN FLATS

1. Flat with paper pot fillers and galvanized steel bottom (shown above). The plants are ready for setting without loss of roots. 2. Plants taken from flat.

CHAPTER IV

SEED TESTING

69. Specialists divide seeds into two classes—those whose botanical purity can be determined from the specimens themselves and those which can be judged only by the plants they produce. Most farm seeds belong to the first class; most garden seeds to the second. Hence, the former are the more easily tested and their value for sowing more accurately judged beforehand. With the latter the point of most importance is trueness to name and strain. Of course they must germinate, but gardeners would rather have low vitality seed of good stock than high vitality seed of poor stock; for though they might get only 25 per cent of plants from a sowing, these would be of the type they desire; but even 90 per cent in the other case might mean no sale for the product. Most good seedsmen, therefore, test their stock.

FIG. 31—TWO STYLES OF TROWELS
Left, properly cared for; right, improperly

The importance of this was recently told the writer by a prominent seedsman whose firm took a contract to furnish a canning factory with a large quantity of best seed. The seed firm was obliged to buy the seed to fill the order. No test was, therefore, possible prior to filling the contract. The seed proved to be so inferior that the seed firm promptly met the loss of $1,200 when the canning company made complaint.

70. The value of "trial grounds" to seedsmen and to the public cannot be overestimated. The firm's stocks and those of competitors are grown side by side, and as the season advances, critical observations are made, with the result that inferior stock is discovered and disposed of in ways that will do no harm.

71. The importance of seed analysis is threefold: a, seeds are the most variable materials farmers have to buy; b, weight for weight they are the most costly; c, the success or failure of the immediate crops and often of several generations of crops depends largely or perhaps even wholly upon the character of the seed. Hence seed testing is almost essential to the modern farmer who must leave no point to chance.

Borlase furnishes an example in the following table and comment:

VALUE OF SEED ANALYSIS ILLUSTRATED

Sample	Pound Price, Cents	% Good Seeds	% Inferior Seeds	% Weed Seeds	Number Seeds in Pound	Number Good Seed for a Cent
1	*25	97.1	1.7	1.2	213,620	8,906
2	*20	78.6	13.4	8.0	172,920	8,640
3	*18	60.3	28.1	11.6	132,660	7,370

*Price approximate, hence "number good seed for a cent" also approximate.

FIG. 32—EFFECTIVE MEANS OF HASTENING GERMINATION

1. Seedlings under inverted flower pot. 2. Seedlings under pane of glass.

If only 10,000,000 seeds are sown to the acre, Sample 1 would provide over 20 weed seeds to the square yard, while Sample No. 3 would distribute 240. But notice also the number of good seeds obtained for a cent and figure out how much is being paid for inferior and weed seeds in each case; then judge the help that pure seed will be in preventing weed growth on the farm.

The Canadian Department of Agriculture found that "red clover" seed sold in Ontario contained 6,000 to 15,000 weed seeds to the pound and in alsike as high as 23,550 to 49,830.

An American sample of alfalfa gave 6.8 per cent or about 32,500 seeds in a pound of weed seeds, including 5.490 of dodder (see C, 72), one of the worst of weeds, because, being parasitic, it kills all the alfalfa it reaches.

FIG. 33—RHIZOMES

1. Iris showing old rhizome at left and new at right. 2. Rhubarb rhizome.

In certain parts of the United States, it is stated, clover seed tailings are sometimes used on the farm, the clean seed being sold. Such tailings have been found to contain over 272,000 weed seeds to the pound. Such seed will soon make any farm a weed paradise.

72. Losses due to low-grade seeds are evident from the examples cited. These may be grouped under the following heads: A. Direct loss on the purchase. B. Loss of crop due to insufficient good seed sown to the acre, with possible total loss in worst cases. C. Loss due to direct destruction of crop because of introduced parasites such as dodder and broom rape. D. Necessary cost of extra cleaning the seed

crop, perhaps even for several years, due to the introduction of weeds. E. Damage caused by introduction of new weeds, which may spread over the farm or the district. F. Loss due to insect and fungous pests introduced with the seed.

A. Direct loss following the purchase of low-grade seeds may be due to one or both of two factors: (1) reduced quantity of seed true to name, and (2) poor germinating capacity of the seeds. Usually low quality seeds are poor in both ways.

B. When truly high-class samples of seed are bought, less seed is needed for a given area than when low-grade samples are used. When a low-grade sample is sown unwittingly, the result may be a poor stand, which may be overcome by strong growing weeds, many of which may have been introduced with the seed. Sometimes the whole field may have to be plowed and re-sown, thus causing loss of cultivation, one lot of seed and much time, the last, perhaps, most serious, except the equivalent loss of money.

C. The loss due to parasites may be calculated from the statement by M. Marre that a single dodder stem may spread so rapidly in three months as to kill clover or alfalfa on an area of about 30 square yards! By experiment, dodder seed has been found to germinate when only half ripe! The seeds of the dodder and broom rape may lie dormant in the soil for several years.

D. Introduced weeds may make necessary extra cultivation as well as extra cleaning of the seed crop.

E. See comment above (F).

F. See comment above (C).

On every count, therefore, low-grade seeds are undesirable at any

FIG. 34—
POTTING ROOTED GERANIUM
1. Ready to fill. 2. Filling in soil. 3. Firming in pot.

price. Low price is almost surely an index of low quality.

73. Questions to consider in testing seed.—1. Is the seed to be purchased truly named? If not, it should be refused. Seed purporting to be *Trifolium repens* (white clover) but really *T. parviflorum* (a worthless clover species) should be refused and the seller perhaps sued for fraud. Species can usually be identified, but varieties must generally be grown before they can.

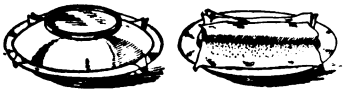

FIG. 35—SMALL SCALE SEED TESTING

2. Is the seed fresh or old? Old seeds may be treated to make them look fresh, but that won't put life in them. When mixed with new seed they reduce the value because they are probably dead. This trick of the trade is far less practiced than formerly. It constitutes a fraud and is punishable by law. Mere number of years does not necessarily make seed "old." Some seeds (see table p. 49) retain vitality ten or more years. They properly deserve still to be called "fresh" if they germinate well. Reputable seedsmen, after testing their "returned" seeds offer the good samples for sale again. This is perfectly legitimate.

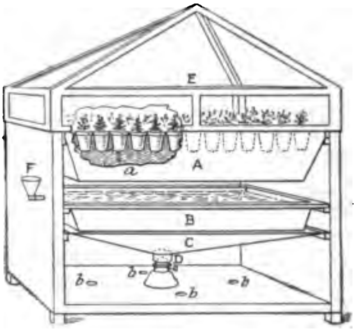

FIG. 36—ELABORATE PROPAGATING OVEN

A, galvanized iron earth tray; a, plants in pots; B, water tank filled by funnel, F; C, chamber heated by lamp, D; b, b, air intakes; E, removable top.

3. Has a cheaper seed been mixed with the desired kind? Yellow trefoil seed superficially resembles, and is sometimes used to adulterate, red and alsike clovers and alfalfa. Cock's-foot grass seed may be adulterated with meadow fescue or perennial rye grass and charlock seed, perhaps baked to kill it so its seedlings will not betray the fraud, may be mixed with cabbage, rape and similar seeds.

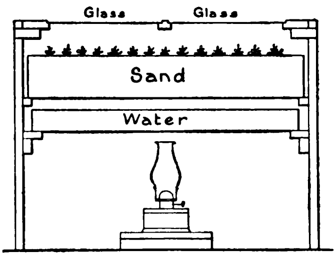

FIG. 37—SIMPLE PROPAGATING OVEN

With dimensions at 2 feet high the glass would be 10x12 inches.

4. How pure is the sample? The percentage of seeds true to name is of great importance. The impurities should be identified—weeds and their species, seeds of other cultivated plants, chaff, bits of stem, leaf and pods, dirt, etc. Very bad weed seeds should be

named. "Rubbish" impurities are of small consequence compared to weed seeds, especially if bad; for instance, a sample of clover 99 per cent pure and with 99 per cent germination, would be unsatisfactory if it contained dodder.

5. What does the seed weigh? Generally heavy seeds within the limits of the species are best.

6. Are the seeds dry? Well-dried seeds keep best and give best results.

7. Where did the seeds originate? Seeds from some countries or even localities may be better or poorer than from others.

8. What percentage will germinate? And at what rate or "strength"?

9. What percentage are "hard" seeds? Perhaps this will not be considered as serious a question as formerly when the sulphuric acid method (47) comes into more general use.

FIG. 38—SAND BOX SEED GERMINATOR

The wires divide the surface into squares in which the seeds are placed.

74. Simple conveniences in seed testing include a pocket lens to examine small seeds; sheets of stout white paper or cardboard on which to spread seeds for examination; a spatula-like piece of hardwood, bone or celluloid to separate the seeds; tweezers to pick out small seeds; a small scales for weighing phials of truly named cultivated plant and weed seeds with which to compare seeds to be examined; gummed labels for numbering or naming samples; blotting paper, strips of flannel, and clean sifted sand for germination tests.

A small germinator may be made by wetting sand in a

soup plate, placing blotting paper or flannel on this, then the seeds to be tested next, a second sheet of blotting paper and finally an inverted soup plate to check evaporation (Fig. 35). For small seeds, Petri dishes used by bacteriologists are more convenient than soup plates, because they take up less space. A warm room will supply the needed heat. Seed pans and flower pots placed in trays of water or otherwise kept damp are useful in a

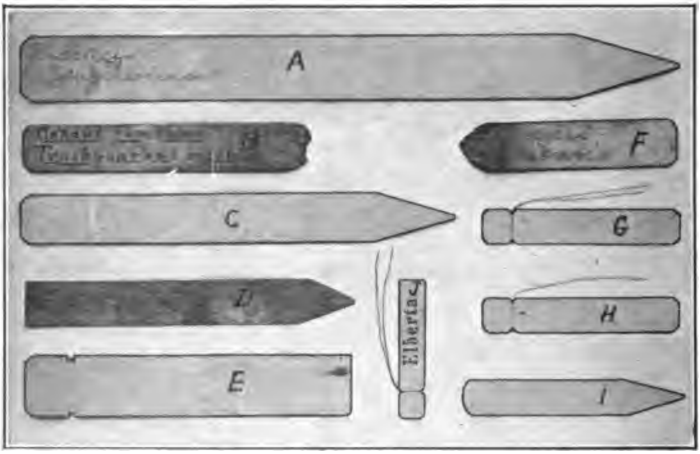

FIG. 39—LABELS AND METHODS OF MARKING

A, C, I, various sizes of florists' labels. B, old label rotted off at bottom without losing name. D, zinc label with writing almost illegible after a year or more of use. E, G, H, nurserymen's labels for fastening to trees etc. F, old label showing wrong way to write name, thus losing the important part, the first syllable or two, by decay. J, nurserymen's label printed on both sides for quickness in handling.

larger way. For more extensive work, as in schools and colleges, germinating ovens (Figs. 36, 37) will be found more convenient and useful.

75. Conducting a seed test.—Representative samples of the seed to be tested are taken from the sacks or bins of seed. These are mixed to secure uniformity. A small sample of this composite sample is weighed, spread out and the good seed separated from the bad and the various

impurities, each by itself. Then each lot is weighed and the percentage of purity computed. From the pure lot thus separated, 100 or 200 seeds are selected and placed in a germinator so they do not touch each other. In due time under favorable conditions, sprouting will follow and the percentage of germination may be determined. To calculate the true value of the seed, multiply the percentage of purity by the percentage of germination and divide by 100. For instance, suppose a sample to be 90 per cent pure and have 80 per cent germination; $90 \times 85 \div$ by $100 = 83.3$ per cent. That is, 100 pounds would contain 83.3 pounds of pure, germinable seed and 16.7 pounds of dead seeds, weed seeds, dirt, etc. What man in his right senses would pay for the latter?

76. The longevity of seeds, the percentage of germination and the purity of the sample have much to do with the resulting crop. In the table on page 49, the percentages of purity and germination (by Duvel) are high averages in high-grade seed; the figures (years) on longevity are from Vilmorin. As an indication of the importance of securing high-grade seed the following instance speaks for itself.

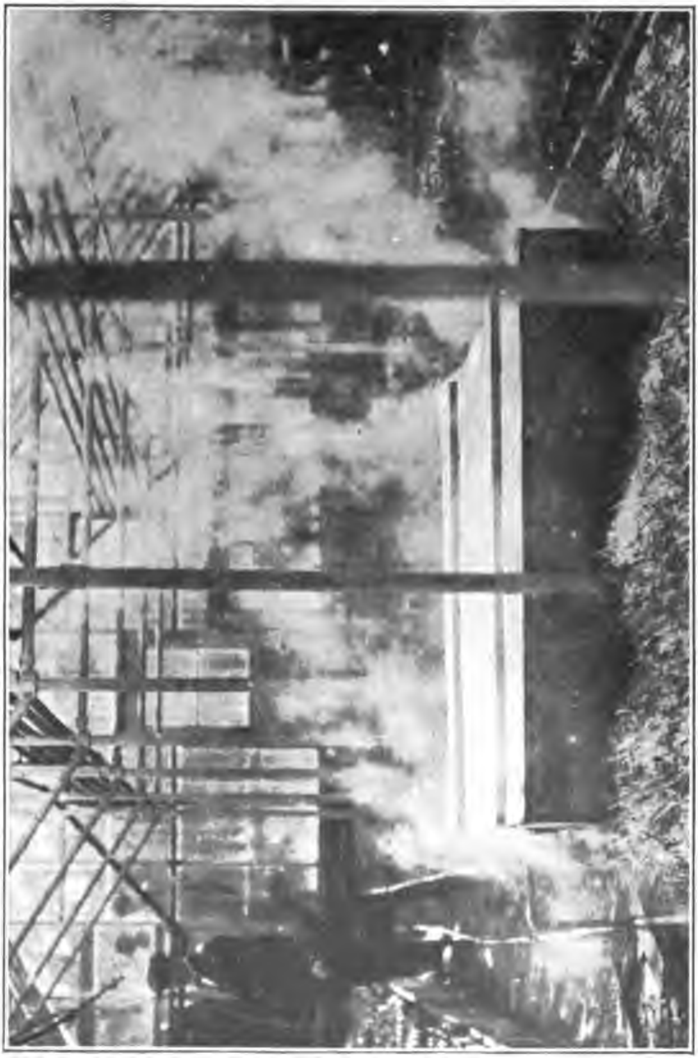

FIG 40—BOX METHOD OF STEAM STERILIZING GREENHOUSE SOIL

The straw mat in the foreground has been placed over the soil just steamed to hold the heat as long as possible.

GERMINATION AND LONGEVITY OF SEEDS

[Purity and Germination figures from Duval; Longevity from Vilmorin.]

Kind of Seed	Per Cent Purity	Per Cent Germination	Average Longevity	Kind of Seed	Per Cent Purity	Per Cent Germination	Average Longevity
Alfalfa	99	95	-	Grass, Timothy	99	96	2
Asparagus	99	85	-	" Velvet	97	85	-
Barley	99	98	3	Hemp	99	90	-
Beans	99	98	3	Kafir Corn	99	97	-
Beet, Garden	99	150*	6	Leek	—	—	3
" Sugar	99	150–175*	6	Lettuce	99	98	5
Buckwheat	99	96	2	Mustard	99	95	4
Cabbage	99	95†	5	Oats	99	96	3
Carrot	98	85	4 or 5	Okra	99	80	5
Celery	98	85	8	Onion	99	96	2
Clover, Alsike	98	95	-	Parsley	99	80	3
" Crimson	98	97	-	Parsnip	98	85	2
" Red	98	95	3	Pea	99	98	3
" Sweet	98	90	-	Radish	99	97	5
" White	96	90	-	Rape	99	96	5
Corn, Field	99	99	2	Rice	99	95	-
" Sweet	99	94	2	Rye	99	96	2
Cotton	99	90	-	Salsify	98	85	2
Cowpea	99	95	-	Sorghum	98	95	-
Cucumber	99	96‡	-	Soy Bean	99	95	2
Eggplant	99	90	6	Spinach	99	90	5
Endive	99	85	10	Sunflower	99	90	-
Flax	99	95	2	Sweet Pea	99	90	-
Grass, Blue	95	85	-	Teosinte	99	90	-
" Brome	90	90	-	Tomato	99	94	4
" Fescue Meadow	98	90	-	Tobacco	99	90	-
" " Sheep's	96	85	-	Turnip	99	98	5
" Millet	99	90	2	Velvet Bean	99	90	-
" Orchard	95	90	2	Vetch	99	93	-
" Red top	96	90	-	Wheat	99	98	2
" Rye	98	90	-				

* Beet "balls" usually contain two to six seeds—the figures are for 100 balls tested.
† Kale, cauliflower, collard, kohl-rabi, etc., have same figures.
‡ Other vine crops—pumpkin, melon, squash, etc.—have same figures.

77. Does it pay to test seed for germination? C. E. Myers has furnished me the following figures on tests of crimson and sweet clover seed made prior to purchase. From three and two seedsmen respectively, he received samples and prices.

GERMINATION TEST OF CRIMSON AND SWEET CLOVER SEED

Seed Samples	Price	Percentage
Crimson Clover, Sample 1	$6	92
" " " 2	6.70	78
" " " 3	5	94
Sweet " " 1	15	82
" " " 2	17	66

In these two series of tests it happened that the lowest priced seed gave the highest germination and the most expensive the lowest. Since the amount of time required to make the tests was scarcely more than an hour and the cost certainly not more than 50 cents for each series, it is evident that a saving of $1 to $1.70 on the crimson clover and $2 on the sweet clover was made

FIG. 41—STERILIZED VS UNSTERILIZED SOIL

A, soil sterilized by heating before sowing; B, unsterilized soil. Notice weed growth.

on each bushel of seed bought, even without considering the higher percentage of plants likely to follow sowing these seeds. One interesting point in these tests is that the seedsman who quoted the lower price on sweet clover also quoted the highest on crimson clover.

It must not be inferred from these instances that cheap seed is always or necessarily the better to buy. On the contrary low-priced seed is perhaps far more often the more expensive because of its probable dirtiness and low percentage of germination. *Nothing but an actual test can determine this point.*

78. Damping-off is a nurseryman's and gardener's term for the decay of seedlings and cuttings, more especially just above the surface of the ground. The conditions that favor it are excess of moisture in both soil and air, higher temperature than necessary for normal plant development, and poor light. The weak plants that develop under these conditions succumb to tiny fungi which live upon decaying vegetable matter in the soil, and which

FIG. 42—FRAMES FOR STRAW MAT MAKING

These are homemade contrivances. Nursery and greenhouse supply houses make mats by machine.

live for months in spite of drouth or of frost. Should damping-off be noticed the healthy plants should be pricked out (81) or transplanted in fresh soil to save them if possible. So rapidly does the trouble spread that thousands of seedlings or of cuttings may be lost in a single night. Perfect drainage in open soil with ample watering and fresh air are partial safeguards. Steam sterilization (Fig. 40) of the sand for several hours is often done with good results. Damping-off frequently follows copious watering of a bed which has been very dry longer than advisable.

The fungi usually believed to cause damping-off are *Phytophthora omnivora* (*Fusarium* sp.), *Pythium debaryanum;* but V. Peglion, an Italian investigator, has identified several others—*Botrytes cinerea,*

Thielavia basicola and *Phoma beticola*. By experimenting with soil infested with *Pythium debaryanum*, heating to 130 to 212 degrees and treating with 20 to 30 per cent solutions of formalin and various quantities of carbon bisulphide, he found that Camelina, a plant very susceptible to attacks of this fungus made good growths, the action of this fungus being reduced even to nothing.

79. Damping-off seedlings in plant beds, according to the Minnesota station, is commonly caused by *Pythium debaryanum* or Rhizoctonia. These attack a large variety of plants as well as live upon dead organic matter in the soil. Very little can be done to check the disease when such conditions prevail. Therefore methods which kill fungi are needed to prevent the disease. The preventive methods must be applied before sowing the seed, otherwise the seed will be killed also.

FIG. 43—WORK IN THE CUTTING BENCH

1. Opening a furrow with a wooden label. 2. Firming the cuttings in the sand, side view. 3. End view. 4. Removing rooted cuttings for potting.

Chemical agents have been tested as fungicides against damping-off, but of these formalin alone has proved of value. Treatment of the soil with formalin (one part formalin to 100 of water and lesser strengths), as frequently recommended, does not kill the fungus. Although it may check the disease for some time it will allow damping-off to develop later if weather conditions permit. The value of formalin at these strengths, therefore, depends largely on the time weather conditions favorable to damping-off appear.

Treating the soil with 1-50 formalin at the rate of two quarts to the square foot of soil, will kill damping-off fungi, and will hence effectually prevent the malady under the most favorable weather conditions for fungous growth. Formalin soil treatment is also somewhat beneficial in stimulating plant growth and in killing some weed seeds. The chief objections are the cost, the time required for it to act, and for the soil to dry out.

[If the fungus gets into the cutting or seedling bed it may be checked more or less by withholding water and allowing the sun to reach the sand or soil of the bed.]

80. Sterilization of the soil by heat has proved most satisfactory from all standpoints, except that under certain conditions it may be more expensive than formalin. Steam sterilization by the "inverted pan" method is especially recommended where a steam traction engine is available. [The temperature of the soil should reach 210 degrees at the bottom of the bed for at least 30 minutes.]

Aside from preventing damping-off several beneficial secondary effects may follow; for instance, killing of weed seeds and insect pests, and greatly increased size and vigor of plant growth. As a cultural control growers should avoid infected, poorly drained soils and thick sowing of seed. The only means of checking the disease after it has started is to remove the covers in order to reduce the temperature and the moisture of the soil and of the air immediately above the plants.

The United States Department of Agriculture secured best results in treating soil for damping-off of coniferous seedlings by drenching with dilute sulphuric acid (one ounce to one gallon) several days before seed sowing and a week after the seedlings appeared. In December there was a fine stand of healthy seedlings on the treated plot and the soil was free from algæ and moss, while the check plat was green with algæ and moss and there were practically no seedlings left. Only Norway spruce seemed to suffer. For this plant a weaker solution (1 part to 500) is recommended.

According to another source, damping-off may be prevented by "treating the soil with dilute iron or copper sulphate."

81. Pricking out (or off) is a gardener's term for transplanting seedlings while yet so small they can easily be lifted on a stick scarcely wider than a toothpick at its sharpened end. A better form consists of two points which form a blunt **V**. The seedlings are thus moved from the seed pans and placed in other flats at greater distances apart, say an inch, until better rooted. Pricking out is done also to avoid risk of damping-off (78).

CHAPTER V

POTTING

82. Potting, placing of rooted plants in flower pots.

83. Potting soil should be light and friable so as to handle easily, drain readily and withstand crusting and baking after wetting. It should also be fertile in proportion to the needs of the plants to be grown in it—rich for some, poor for others. Also its friability must vary; for ferns be looser than for roses.

FIG. 44—POTTING SOIL MIXED AND UNDER COVER

This soil has been passed through a machine "mixer" and is sifted, also by machine, ready for use.

84. Preparing an ideal soil for potting. The best general potting soil is made as follows: In spring after grass has begun to grow well, remove sod from an old blue grass pasture or greenhouse sodding field where the soil itself is rich and deep. For convenience in handling, cut the sod in strips a foot or so wide, three inches thick and as long as can be easily handled either in rectangles or in rolls, the latter perhaps preferred. Place the sods close together on the ground in a layer, grass side

down, on a well-drained space adjacent to the greenhouse. Convenient widths are 6 to 10 feet. On this layer place two or three inches of well-rotted manure and sprinkle pulverized lime on it—say, a scant pailful to the square rod. Repeat alternate layers of sod and manure until a pile three to five or six feet high with sloping sides and of any desired length has been made. It is an advantage to make the top concave, so it will hold water when needed.

Let the pile stand thus for two years or longer before being used. Then slice with a sharp spade vertically from top to bottom and mix thoroughly by throwing in a heap as slicing proceeds. At the same time, add enough sand to be plainly visible on the pile.

FIG. 45—SIFTING SOIL FOR POTTING
The hand method of getting rid of clods and stones.

Commercial greenhouse men cannot usually afford so expensive a soil as this because of the cost of the turf and the loam—often $100 to $200 an acre for the surface three or four inches. They, therefore, use a rich garden loam with liberal quantities of compost and sand. For houses where little of the earth is sold with the plants the soil is returned to the field after being used in the greenhouse and there liberally fertilized and made to grow crops of clover, rye, buckwheat and grass, each crop plowed under to fill the earth with vegetable matter for its next journey to the greenhouse. In such cases the soil is generally run through a mixing machine before it is used. Thus the soil area actually becomes richer and more friable from year to year.

85. Flower pots are of two principal kinds; those with and those without rims. They range in one-half-inch sizes between two and seven inches, and in one-inch sizes between 7 and 12 inches. Between two and two and one-half is a two and one-fourth-inch size. There are also 14, 16, and 18-inch sizes, but tubs and boxes are usually more satisfactory and less expensive in these and larger ones. Sizes below 16-inch are machine made in "standard" form. Straight-sided pots are little seen nowadays. Below the two-inch size are "thumbs" used for tiny plants.

Azalea or three-fourth pots are most useful for growing ferns, azaleas and other house plants, lilies and many other bulbs. They afford ample soil and root room, are not as unsightly as full-sized flower pots of the same width. Their "low down" effect is more pleasing to the eye than is that of the tall pot.

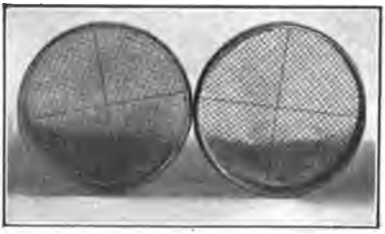

FIG. 46—GREENHOUSE SOIL SIEVES
For fine work with seedlings, ferns, etc.

"Seed pans" are earthenware trays usually one to two inches deep. They the most largely used for growing ferns, seedlings of small-seeded plants, etc. For this purpose they excel pots.

The rimmed or "standard" pots (Fig. 21), though easier to grasp are harder on the hands than are those without collars when large numbers must be handled in a day, yet they are so popular that the old style collarless ones are almost a curiosity in many sections of the country. Whichever style is chosen, it should be porous, never glazed. When to be first used, the pots should be dipped in water a few minutes and the surface water then allowed to evaporate. The pores of the pottery must be filled with water but the pots must not be wet when plants are set in them.

In many greenhouses old and dirty pots are no longer washed, because when expense and breakage incident to washing is reckoned, the cost is found to be too near that of new pots to pay.

86. The operation of potting is capable of a high degree of skill and speed. It is no unusual feat for a man to

FIG. 47—TOMATO PLANTS IN PAPER AND EARTHENWARE POTS
The paper pots readily rot, so may be left around the plants when transplanted.

pot 5,000 rooted cuttings in 10 hours. The highest record which has come to the author's attention is 11,500 verbena cuttings in 10 hours. This was made in the greenhouse of the late Peter Henderson of New York by "Jim" Markey, who did only the potting, two boys keeping him supplied with soil, pots and cuttings and taking away the potted plants.

Elimination of waste motion is the secret of such

speed. Everything is arranged conveniently for a right handed man as follows: The soil is piled on the potting bench. At the left are the empty two-inch pots, in front are the cuttings, at the right an empty flat for the potted cuttings. Both hands work at once thus: 1. The right seizes a handful of soil, the left an empty pot. 2. The pot placed in front of the operator is filled with part of the soil in the right hand while the now released left hand seizes a cutting. 3. The index finger of the right hand is thrust in the soil in the center of the pot, the left places the cutting in it. 4. The right discharges some soil around the cutting and both hands seize the pot be-

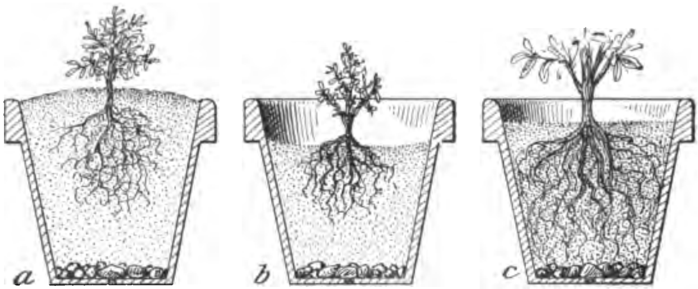

FIG. 48—WRONG AND RIGHT WAYS TO FILL POTS
A, too full; b, not full enough and plant too deeply set; c, right.

tween the first and second fingers, the index fingers being on side of the pot remote from the operator's body. This holds the pot firmly while (5) the thumbs, first parallel with, and then at right angles to the body, one on each side of the cutting, press the soil firmly and uniformly. Then, 6, the right hand places the filled pot with a smart rap in the flat and the left hand seizes another empty pot. If the motions are practiced slowly and carefully at first, speed will soon develop as the hands learn to make no false moves. Just as good work can be done speedily as slowly!

87. Care needed in potting.—Simple though potting is,

it must be properly done to get good results. Many losses of potted plants are due solely to carelessness. The potting soil must be neither too dry nor too wet, just the condition that when squeezed firmly in the hand it leaves the impress of the fingers and shows several little cracks in it, but does not break down (too dry) nor remain as a gob of mud (too wet).

The plants must be set at just the right depth (Fig. 48), otherwise they will fail. Seedlings and cuttings must not be placed in pots too large for them. The almost universal size to start with is two-inch, though many ferns and other little plants are set at first in "thumb" pots, a still smaller size. The roots of cuttings must neither be too large nor too small, because in the

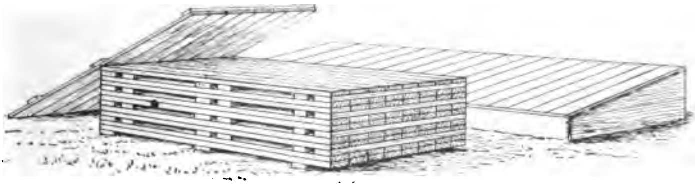

Fig. 49—SHUTTERS FOR COVERING HOTBEDS AND COLD FRAMES

Notice positions of the cleats. This arrangement favors easy piling and good ventilation for drying.

first case there would be breakage, in the latter refusal to grow; one-eighth to one-fourth inch is about the usual length for speedy work.

Always a two-inch pot should have a vacant space one-fourth to one-third inch deep at the top for water. The pots, when placed on the greenhouse bench, must be set level so as to avoid loss of water over the edge. At first the plants need shade. Lath shutters (Fig. 49), in general use, are placed on inverted pots large enough to raise them above the plants. In hot, sunny weather, newspaper or cheesecloth is used for additional shade for three days to a week at first, being placed early and removed late in the day, but gradually shortening the time shaded.

Sand to the depth of one-half to one inch on the bench aids greatly in the retention of moisture as well as in placing the pots level.

Repotting dangers.—It seems to be a rule that plants grown in the open ground attain larger size than those grown in flower pots; also that those grown in large pots grow larger than those grown in smaller and smaller ones. Experiments have proved that the greater the number of repottings the smaller the plants so treated.

88. Tomato propagation.—In Maryland, 83 varieties of tomatoes were grown experimentally, some in the usual way of transplanting, some from seed sown direct in 4-inch pots imbedded in earth and the seedlings thinned. There was loss by damping-off among the

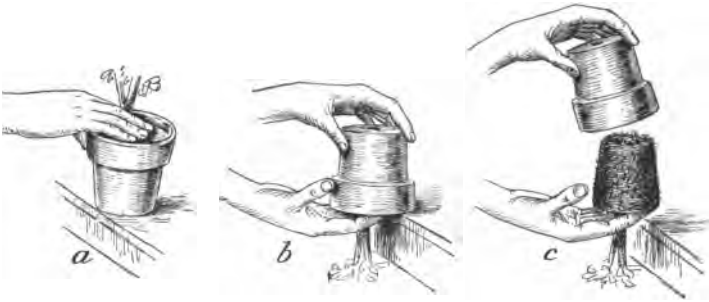

FIG. 50—REMOVING PLANT FROM POT

A, placing the hands; b, rapping pot on bench to loosen ball of earth; c, plant separated from pot.

transplanted plants, but none among the pot grown. These latter suffered no loss or check when moved to the field; the transplanted plants were slower to start and to bloom. With 72 of the 83 varieties the pot plants yielded more than the others, and among the 10 greatest yielders nine were potted. The average yield on an acre basis was 12¾ tons, against 10¾, an increase more than enough to pay for the labor. The potted plants, as a whole, produced about twice as much fruit prior to August 15 as the others—59 bushels, against 30. [This is of special interest from a market standpoint, because of higher prices early in the season.] Each of the 20 best early producers gave greatest yield from the potted plants.

89. Transplanting lettuce and other plants experimentally in Wisconsin in the greenhouse seems to warrant the general conclusion that transplanting does not promote earliness nor increased yield. Once transplanting, as of cabbage plants, from seed bed to field, or "pricking off" as commonly practiced in the greenhouse, is necessary to economize room, but repeated transplanting of vegetable plants is not advisable.

90. "Shifting" is the trade term for transferring potted plants to larger-sized pots. At a glance the trained man can tell when shifting is needed; the novice may "knock out" the plants to examine the roots. This is done as shown in Fig. 50, the top of the pot being rapped smartly on the edge of the bench. If the roots form a network around the earth, especially if they are dark colored, they must be shifted to avoid becoming "pot-bound."

91. In knocking out plants for shifting, only one rap is

FIG. 51—POT STORAGE OUT OF DOORS

This being placed adjacent to the cold frames and hotbeds saves much time and labor.

usually needed; more waste time. Plants should never be shifted while the soil in the pots is either very wet or very dry; only when dry enough to crumble beneath thumb and fingers. Pot-bound plants need special attention (92). Pots should be free from caked dirt and fairly clean. After removal from the small pots, each plant is "shouldered"; i. e., part of the surface soil is rubbed off so fresh soil may take its place in the larger pot in which it is to be placed.

Plants, soil, pots and flat being ready, the workman puts enough soil in the bottom of the pot to have the top of the ball of earth around the plant on a level with the rim of the pot. The plant being so placed by the left hand, the right hand fills in soil; the pot is then grasped as in motion 4 above (86), raised slightly and rapped twice on the bench, the thumbs pressing the soil as in motion 5, first in one position then in the other. The unpressed earth is then firmed in the same way and the shifted plant set in the flat at the right. Expert shifters with two boys to keep them supplied with material and to remove shifted plants easily shift 5,000 plants a day.

FIG. 52—FLAT FULL OF PLANTS READY FOR TRANSPLANTING

Canned tomato boxes make three convenient-sized flats each, when sawed apart twice around the sides.

Shifts should be from small pots to the next size larger. Never skip a size in the fall, though sometimes with quick-growing subjects in spring a size may be skipped; that is, a plant in a three-inch pot may be placed in a five-inch size, or a four-inch in a six. Usually a size at a time is best, particularly in commercial establishments, where the aim is shipping. When pots become larger than four-inch, and even in that size for shrubbery plants, drainage is necessary. "Crocks"; that is, broken flower pots, are the orthodox things. A large piece is placed over the drainage hole in the pot and smaller pieces above to the depth of an inch in five and six-inch pots and twice as much in larger sizes. Pots larger than

three inches should be set on gravel, cinders or other loose material to insure drainage.

92. Pot-bound plants, those which have been checked by remaining too long in the same pots and have been thus checked in growth, need special attention. Before knocking out, the surface soil should be scraped clean to remove "moss" and some of the sour soil. After knocking out, the hard ball of earth should be crushed between the palms of the hands, perhaps broken by raps of the closed hand. The plants may then be replaced in the same pots with additional fresh soil. In most cases, however, it is better to stand the plants, pots and all, in water, say half an hour, and then wash and work out the earth in water either in a tub or in a gentle stream. After washing, the plants should be placed in pots one or

FIG. 53—COMMON LAYERAGE

A, the branches are bent down and buried. B, the layer enlarged to show wound to hasten root production.

two sizes smaller than those they have been in. Shrubbery plants should be pruned back. Plenty of shade but little water is needed until the roots "take hold" and danger of wilting has passed. The appearance of new growth is the favorable sign.

93. Flat, a shallow box in which seeds are started and seedlings grown until large enough for pricking out (81) or transplanting, usually of a size easy to handle when filled with two to four inches of soil. It is convenient to have flats of some standard size that will fit the bench or hotbed space without waste.

CHAPTER VI

PROPAGATION BY BUDS—LAYERAGE

94. Layerage is the rooting of stems while still attached to the parent plant. The rooted pieces are cut off to form new plants. Many species propagate themselves naturally by various modifications of layerage and many which cannot readily be propagated from cuttings (black raspberry) easily do so by means of layers. Layering is one of the easiest and most popular methods of propagation. The parent plant supplies food to the layer until this is capable of caring for itself. In outdoor practice the operation is best performed in early spring.

Grape, bitter sweet, Virginia creeper, honeysuckle and other vines when trailing on the ground become imbedded more or less in earth and take root at the nodes. Blackcap raspberry stems arch themselves till their tips touch the earth, when the terminal buds turn upward, and roots are produced from the thickened ends. Other buds near the tips send out shoots which also take root.

95. Styles of layering. Layering is practiced in many

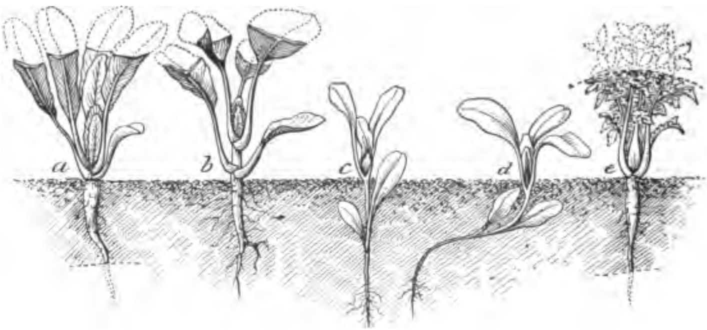

FIG. 54—TRICKS IN TRANSPLANTING

a, b, and e, dotted lines show parts of tops removed; c, and d, show method of handling "leggy" plants

ways, chief among which are: Simple, compound or serpentine, continuous, mound or stool, Chinese or pot.

96. Simple layers (Fig. 55) are made by bending and covering the branches with more or less soil. In general, a shallow and short trench or a small hole is made in the earth and the branch pegged or weighted down in it prior to being covered with soil to the depth of two or three inches but with 6 to 12 inches of the extremity of the shoot uncovered to draw sap and elaborate plant food. To hasten root formation the stems are often wounded

FIG. 55—LAYERING OF VARIOUS KINDS

A, ordinary layering; a, layering pegs; B, continuous layer; C, serpentine layer (alternate nodes pegged down). D, mound or stool layer.

at the points to be covered. Wounding may be done by scraping the bark or cutting through the cambium layer on the lower side of the branch below the bud or shoot to grow, or it may be by severely twisting the branch at this point. Hacking with a knife near the node is also often done. These woundings tend to form adventitious buds on which root growth in asexual propagation depends.

So many species and varieties of shrubs may be propagated by simple layering that it seems probable any woody plant capable of being bent to the earth can be thus propagated. (Currant, gooseberry, golden bell.)

Black raspberry canes and shoots cannot be made to root well when covered at more than their tips. (Fig. 56.) When the tips are about ready to take root they

should be anchored with pebbles or clods of earth to prevent whipping about by wind. This is especially important where the ground is hard and dry. Since this method is the only one practiced in propagating black raspberries, it is sometimes called *tip layering*. In the following spring the rooted tips are severed for planting with about six inches of the stems to serve as handles. The buds from which the new canes are to develop must not be set deeper than the surface of the soil.

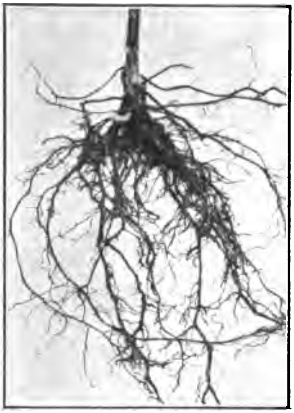

FIG. 56—BLACK RASPBERRY ROOTED TIP
White spot near center is the new bud.

97. Compound or serpentine layers (Fig. 55) are made by covering the stems at several points alternating with other points not covered. The method is most frequently used for propagating vines and other long supple stems. Management is the same as for simple layers.

98. Continuous layers (Fig. 55) are made from plants which root readily when the whole branch except the tip is buried with three or four inches of earth. Since the buds on most plants will not develop into shoots if buried, only a few plants are adapted to this form of layering, among them red osier, willow, high bush cranberry and snowball.

99. Modified continuous layering, popular in propagating varieties and species of grapes and other vines that do not root readily from cuttings, is practiced as follows: In spring new canes are laid in open trenches two or three inches deep and pegged down. When the buds have developed shoots, the opposite sides of the parent canes are wounded at the nodes and earth is drawn over the canes and the bases of the shoots. After

having taken root the canes are cut on each side of a rooted node bearing a shoot. Thus as many plants may be secured as there are shoots.

100. Chinese or pot layers (Fig. 58), used almost wholly in greenhouse practice, are made on upright stems which cannot be readily bent as in simple layering or covered at their bases and treated by the mound method. It is of special use for re-rooting plants with stems that have become "leggy" (dracæna, oleander, croton, rhododendron, rubber plant, pandanus). It is also of service in making the branches of such plants take root.

FIG. 57—HOMEMADE LAYERING POT

While still growing in their natural position, the stems are wounded, usually by girdling or notching, and bound with earth, moss or some other moisture-holding material held in place with raffia or cloth bands. Until roots have developed, the bandage and its contents are kept moist by watering when necessary — an easy matter in a greenhouse. Roots push out from the upper side of the girdle or notch. As soon as they have filled the ball of moss the stem is severed below the wound and planted usually in a flower pot. Sometimes the leafage is reduced, as in

FIG. 58—CHINESE LAYERS
A favorite way to increase crotons.

transplanting. Often special flower pots with open sides (Fig. 57) are used in this method; but as good results are secured with moss alone as with them.

101. Mound or stool layering (Fig. 55), which consists of burying the bases of shrub stems deeply with earth, thus forcing the striking of roots, is of special utility in propagating short-stemmed and stiff-branched shrubs. Quinces, English gooseberries and Paradise apple stocks are so grown. When many plants are desired, it is common the previous season to cut down the shrubs to be used thus so as to produce numerous shoots close to the ground and the center of the shrub. Preparatory to covering, these shoots are wounded close to the ground so roots will be produced quickly in abundance. One season's growth is usually enough to make plants capable of being used for setting out. The advantage of the method is that strong, stocky plants are thus produced.

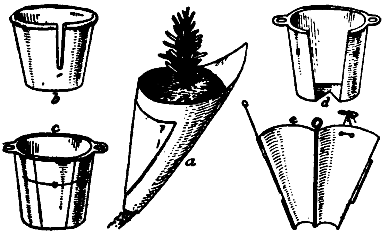

FIG. 59—STYLES OF LAYERING POTS

102. Runners (Fig. 60), special, usually creeping branches formed by strawberry and some other plants, produce little clusters of leaves at each second node from which, under favorable conditions, roots are developed and thus new plants formed. All that is necessary to have the roots develop is to anchor the rosettes of leaves with clods of earth or pebbles for a few days.

Often the runners are made to root in 2 or 2½-inch flower pots plunged full depth in the strawberry bed and filled with good soil. Such plants usually give better results than those allowed to grow without this restriction, because there is little or no loss of roots when the potted plants are transplanted.

Four to eight plants may be produced in succession by one runner; but since the later ones are considered inferior and weak because they have less time in which to grow, only the first one or perhaps two rosettes on any one runner are allowed to grow for making

plants either to transplant or to bear fruit. In field practice no such care as this is taken, the plants being allowed to root freely within the limits of the matted or hedgerow width. As in all other asexual methods of propagation, runners produce the same variety as the parent plants from which they are formed.

103. Rapid strawberry propagation.—C. Gazeau, a French investigator, claims that strawberries may be rapidly propagated thus:

FIG. 60—STRAWBERRY PLANTS READY FOR SETTING

1. Potted runner plant three weeks after taking root. 2. Plant typical of those used in spring setting. This has grown naturally in the field. 3. Same plant as in 1 with earth washed off, compared with plant of same age but not potted.

When the runners first develop terminal buds with rosettes of leaves, they are layered with only the leaves exposed. Thus they are protected from accidents and the weather and are in most favorable conditions for rooting. In about two weeks roots will have formed and the runners extended. These extensions may be rooted similarly and the operation repeated six or eight or even more times. Mother plants often develop six or eight runners, so this would mean 36 to 48 plants thus far. But the first rooted layers will also develop secondary runners soon after the primary ones have struck root and these secondary runners may be treated like the primary ones. Thus the number of plants would be limited almost wholly by the season, the efforts of the propagator and the space at command. But then the terminal buds may be used for making cuttings as soon

as the rosettes have two well-formed leaves, the runner being cut close to its mother plant and the cuttings placed in a propagating bed. The author finds cuttings less successful than layers, the plants being less vigorous and slower to multiply. Only about 35 per cent as many cutting plants can be made as layer plants in a given time. In such work the original mother plants were set about six feet apart each way the previous autumn in a deeply worked and heavily manured bed. The growing season may be lengthened by using cold frames. Intensive culture is essential, so is watering with liquid manure. Plants produced by this method were exceedingly vigorous and yielded abundantly the following year, whereas by the ordinary field method, they did not bear well until the second year from taking root.

FIG. 61—TRIMMING STRAWBERRY ROOTS

104. Bulbs are usually subterranean, specialized buds composed of short rudimentary axes inclosed in transformed and thickened leaves or bulb scales filled with food. Usually they are formed at the bases of the stems, though they often develop from buds inside the parent bulb, generally in the axil of a bulb scale. They are common among plants which have a long resting period, as in arid regions, though they also occur among plants of other regions.

FIG. 62—TULIP PLANTING IN WASHINGTON STATE

1. Making furrows. 2. Placing bulbs. As good bulbs are produced in Puget Sound district as in Holland. The industry is in its infancy

The trade uses the term "Dutch bulbs" to designate those species which come commercially from Holland (hyacinth, tulip, narcissus, etc.), blossom in early spring, and after their leaves die down remain dormant until the autumn, when they develop roots for the following season's flowers. Hence the importance (1) of planting them early in the fall so root growth will be strong before winter sets in, and (2) of allowing the leaves to die naturally so the bulbs will store ample food.

105. Bulblet, bulbel, bulbil, bulbule, are terms concerning which authors do not agree. For instance, one defines "bulbels" as borne attached to the mother bulb, and bulblets as borne above ground, generally in a leaf axil. Another applies "bulbel" to the latter definition and says that bulblet is synonymous with "bulbil." In this book no distinction is made; "bulblet" is most used.

106. Separation is plant propagation by vegetative parts

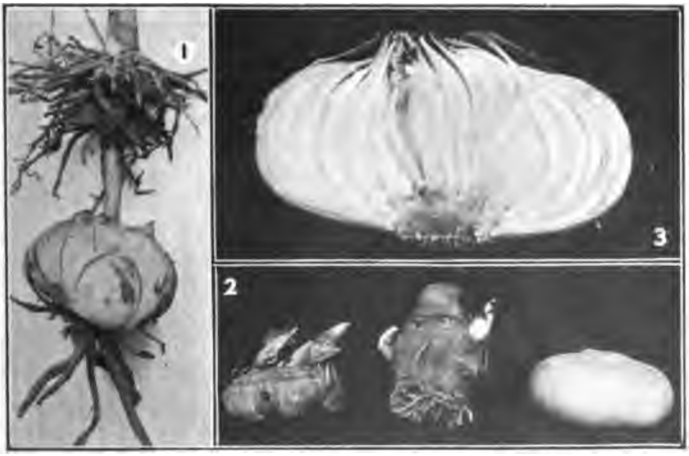

FIG. 63—CLASSES OF BULBS

1. Scaly bulb of tiger lily, 2, solid bulbs (corms) of gladiolus and tuberose and tunicate bulb of onion. 3, tunicate bulb of onion in cross section showing the sheathing bulb leaves.

that naturally detach themselves at the close of the growing season and become or develop new plants.

107. Bulblets are produced from transformed flower buds on stems above ground by top onions, garlic and some other plants; from transformed leaf buds in the axils of the leaves by tiger lilies (Fig. 2); and below ground around the bases of "mother" bulbs.

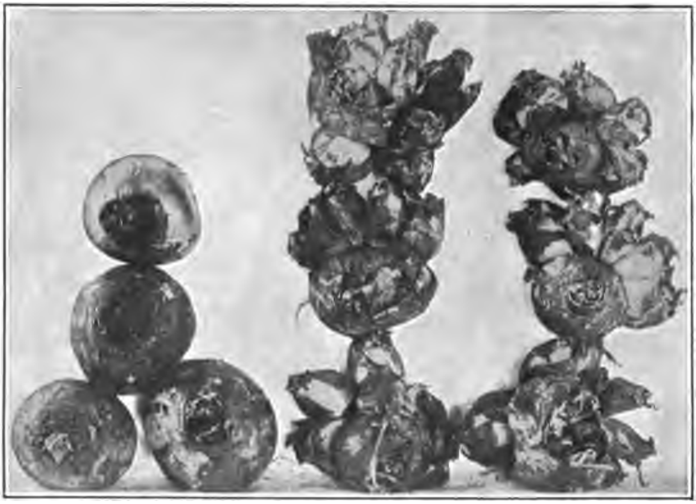

FIG. 64—HYACINTH PROPAGATED NATURALLY
On left, bulbs as offered for sale. Other groups of bulbs naturally splitting up into smaller ones.

108. Bulbs and corms often form a few bulblets or cormels (respectively) around their bases. Sooner or latter these grow to normal flowering size. The larger ones may be separated after the plants are dug. It is, however, usually better to leave the small ones attached to the main bulbs until they are large enough to produce flowers the following season.

109. Bulbs are of three classes: a, scaly (lily); b, tunicate or laminate (onion, hyacinth); c, solid (crocus, gladiolus). Botanically the last are called corms.

110. Scaly bulbs (Fig. 63) are composed of loose, thickened scales which, after the bulb has flowered, may separate in the soil and form new but little bulbs. Advantage is taken of this in propagation.

111. Easter lily bulb propagation from seeds, experimentally, on the Pacific Coast has been found to be quicker than from scales or even smaller bulbs. Under favorable conditions plants will give salable bulbs the first year. The usual sizes secured are five to seven inches, but a considerable percentage of seven to nine is common where good attention is given. The crop ripens in early August.

In the Easter lily industry of Bermuda many scales accidentally broken from the bulbs in digging and handling take root without any care and produce bulbs. The growers rarely take advantage of this method of propagation because enough bulblets are produced to supply the needs of planting. Where the plan is employed, as

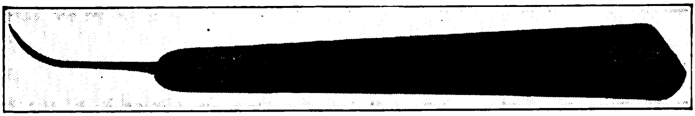

FIG. 65—KNIFE USED TO "SCOOP" HYACINTH BULBS

with rare or costly species and varieties, from a dozen to two dozen of the looser, thicker outside scales are gently cut in mid-autumn to mid-winter from the hard base of the bulb, which thus does not cease to be useful for replanting.

These scales are thrust an inch deep in light, sandy loam in a propagating frame or flats or pots and treated like cuttings.

Damp sphagnum is sometimes used instead of soil. If the soil is kept slightly moist and the temperature under 60 but not below 45, some hardy and half hardy species will form bulblets in a month or even less; others require three months or more. Tender species often seem to need a little bottom heat.

If conditions have been favorable and the scales fully "ripe" when planted one or more bulblets should have developed at the base of each scale. If the planting has been done late, the flats or pots may be placed in a shaded frame outdoors in spring and left there during summer, or the bulblets may be potted as soon as they have rooted and later transplanted in nursery beds. The scales of hardy species are usually left in the flats or outdoor frames all summer and mulched over the following winter. In the second spring they are

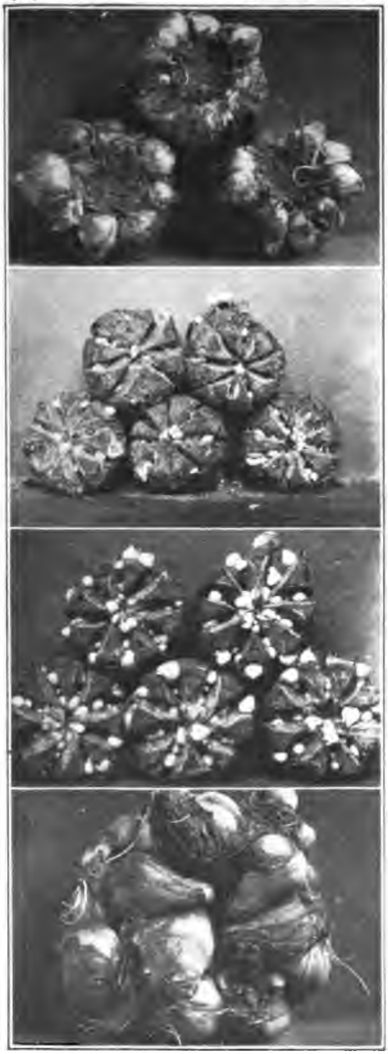

FIG. 66—HYACINTH PROPAGATION

Reading down—natural method; notched bulbs early stage, later stage; final stage. The largest of the bulbs may become large enough for sale in two years.

transferred to nursery beds. At the close of the second season the majority should be large enough for sale.

Lily bulbs are best dug soon after their tops have died. The shorter time they remain out of the ground and the cooler they are kept the better. Small bulblets should be allowed to remain attached to the parent bulbs; but those, half an inch or more across, may be separated and grown in nursery beds another season.

112. Easter lilies from seed.—To avoid lily disease, G. W. Oliver advocates growing Easter lilies from seed rather than from bulbs. He has thus produced plants which bloomed within seven months.

113. Lily bulb disease is caused by *Rhizopus necans,* a parasitic fungus which apparently cannot penetrate unbroken tissues, but gains entrance to the bulbs through broken roots; for bulbs experimented with were not diseased when dug. A brief immersion in salicylic acid or dilute corrosive sublimate solution (1 to 100) will destroy all spores on the bulbs. Daffodils are subject to the same disease. Precautionary measures, such as rotation of crops, avoidance of injury to roots and destruction of refuse, are recommended. When exported the bulbs should first be dipped in the fungicide and allowed to sweat thoroughly before shipment.

114. Tunicate or laminate bulbs. By ordinary, natural increase

only two to half a dozen bulblets are reproduced each year. These ordinarily require one to three or four years to attain salable size. For rapid propagation the bulbs are handled as described by Fred De Meulder in the *Florists' Exchange,* condensed as follows:

115. Hyacinth propagation.—Nature has an easy method of increasing tulips, narcissus, crocus and other bulbous plants. These bulbs, dividing into several parts, multiply themselves without the aid of human skill. Not so the hyacinth, which if left to its own devices, multiplies in such a way that each succeeding generation of young bulbs is more dwarfed than the former, making it impossible to get anything like fair specimens.

It was observed that the hyacinth generally forms bulblets where the old bulbs have been injured. This useful hint has led to purposely wounding the bulbs. Repeated experiments have developed two distinct methods; "scooping" and "notching." In the first (Fig. 69) the hard base of the bulb is cut away, leaving the bottom scooped out; every section or layer of the bulb is thus cut through. In the second method the cutting is done transversely to a depth which the cultivator has learned from experience to estimate.

Each treatment has advantages and drawbacks. Bulbs scooped leave three times the number of bulblets and of much greater vitality, as appears from the preference shown them in the selection of material for forcing. Those notched give less returns, but in a much shorter time, producing flowering bulbs in three to four years, while the others require four to five. More skill is required in scooping than in notching, though a casual observer might say that both are delicate operations. Perhaps the cultivator bases his estimate of the skill needed on the comparative value and number of bulblets endangered, so that operation would be the more critical which is to bring about the better and more numerous bulblets. If gouged out too much, wounding the bulb to the extent of seriously weakening it, a limited amount of enfeebled young bulbs is the result; if scooped not enough, the remaining solid matter at the base effectually impedes or even frustrates the formation of bulblets.

The second method seems to entail as much risk to the mother bulb and her offspring. Transverse cutting looks simple enough; and so it is. But long experience and careful attention have taught the workmen just how deeply to cut. Here again there is danger of seriously damaging the bulb. Cut too deeply, and the whole bulb is lost; not deeply enough, a very limited and dwarfish progeny. Planters differ in their use of the two methods; dividing the annual stock equally between the two is common.

Both classes of bulbs undergo practically the same treatment in the "nurse-room," a place in the bulb house reserved for them and kept at a high temperature. Here they remain until—after a fortnight or so—about one hundred bulblets in the case of scooped

FIG. 67—HYACINTH PROPAGATION

Reading down—cutting the bulbs; nursery storage house; interior of house showing shelves for storing cut bulbs; planting the bulbs after being stored.

bulbs, and thirty in that of notched ones are formed upon them. They are left until after all the other bulbs are planted so as to give them the care of the nursery as long as possible. Then, usually the last week in October or the first in November, they are taken to the field and planted. The ground has been carefully prepared for them; well dug and liberally dressed with well-rotted cow manure earlier in the year. This kind of fertilizer is preferred to others. both because it is cheaper and because it is less harmful to the hyacinth, whose extremely sensitive bulb would be burned up by commercial fertilizers. Hyacinths cannot be set in the same ground except at two-year intervals, or at one-year intervals if the soil is turned up from a much greater depth. Tulips and hyacinths thrive on ground used for each other alternately.

Taken to the field, the bulbs are set in the ground about five inches deep and an area of about five inches square is allowed for each. The flower beds are three feet wide and a path one foot wide is left between them. When all is ready, the whole field is covered with about 10 inches of hay or straw; a necessary precaution, for the hyacinth is very susceptible to cold. The fields lie thus till spring, when tops develop. The flower stems are cut about 10 days after flowers appear to strengthen the bulbs.

The bulbs now begin to enlarge and are left to grow during April and May. About the middle of May, with fair, warm weather, the leaves turn yellow, a sign that the bulbs are matured and can be taken out.

When the bulbs are dug, the new bulblets are the size of acorns; and the mother bulb has almost entirely disappeared, having served as food for her numerous progeny. These are taken to the warehouses and placed on lath frames to dry, merely a matter of plenty of air and ordinary summer temperature. This is also the case with the old bulbs of the "notched" class. The opinion prevalent in some quarters that it is necessary to apply absorbent material to all bulbs after treatment experience has proved to be without foundation. Only in the case of "scooped" bulbs is it found necessary to apply an absorbent.

Cleaning the bulbs, a process always attended with danger of damage, is deferred until fall when an injury will be speedily healed by the earth in which the bulbs are soon after placed. Set in the ground again in October, the new bulbs bear leaves the following spring. The second year those of the notched class flower, while the others need still another season. The flowering bulbs ready for shipment are carefully sorted, packed with chaff in large paper bags or in boxes according to the quantity.

The propagation of some species of tulips must be left entirely to nature; no scientific cutting of the bulb can be done. Left to itself this plant yields three or four bulblets only one or two of which survive and mature. The process of growing the young bulbs is simple. The bulblets appear attached to the mother bulb after the blooming period, the old bulb being "eaten up." The following spring the little ones are removed, cleaned and re-planted, the bulblet thus having taken two years to mature.

116. Corms (Fig. 63) usually produce one to three new ones above the old ones, which shrivel and die. Between the old and the new several little ones called "spawn" are formed. These may be separated and grown a year or two to form large corms. Besides the central bud, from which the flower stem is usually produced, a corm often bears, near its apex, several little buds, which may be artificially made to form new corms (or cormels) by cutting through the substance of the bulb around them. After the original corm has borne its flower stem and leaves, it gradually shrivels and dies and a new corm forms around the base of the stem above the old corm.

117. Care of bulbs and corms. From the garden standpoint bulbs and corms are of two classes: a, spring blooming, b, summer blooming. The former, all hardy, are

FIG. 68—HYACINTH PROPAGATION

Top, harvesting; middle, cleaning bulbs; bottom, machine grading.

planted in fall for outdoor blooming and mulched with leaves or litter during winter. For best results over a series of years their tops must be allowed to mature before being cut or dug. When dug they must be dried in the shade, cleaned and stored in bags or trays in an airy, dry, cool place till fall. Most spring-blooming bulbs (hyacinth, tulips, narcissus) come from Holland.

Summer-blooming bulbs (gladiolus, tuberose, zephyranthes, etc.) are mostly tender. They are planted in spring, usually after the soil has become warm. Because of their tenderness they must be dug before the ground freezes hard, and after drying in an airy shed or other shelter, stored in a dry, warm place such as a cellar with a furnace in it or on boards under greenhouse benches. Before resetting in spring they must be cleaned.

FIG. 69—SCOOPED HYACINTH BULBS

Early and later stages respectively. The bulblets require two to five years to reach salable sizes.

118. Temperatures for bulb storing.—Lily-of-the-valley pips are cold stored at 25 to 30 degrees and bulbs at 17 for the first two weeks, after which the temperature is raised and kept at 24 till the bulbs are needed for forcing in greenhouses.

119. Bulb growing in America. Tuberoses have long been grown extensively in North Carolina; gladioli in New York, Ohio, Kentucky and other states; and other summer-blooming bulbs in various parts of America;

but so far we have no tunicate or scaly bulb industry comparable with that of Japan, Bermuda or Holland. Probably this is because until recently little attention has been devoted to the work. But good bulbs can be grown in this country.

120. The bulb industry in Washington State has been slow to develop, mainly because the rail cost of delivery in eastern markets is higher than the water cost from Europe. The United States Department of Agriculture has for several years been experimenting in this industry and has published a progress report. Virginia grown narcissus, tested at the Department of Agriculture with European bulbs from three sources, gave decidedly better results.

An Illinois experimenter is reported to have grown annually about 100,000 bulbs of tulip, narcissus and lily-of-the-valley on low well-drained, deep, black loam, heavily manured with stable manure. The majority of the bulbs were somewhat smaller than the imported ones, but in earliness and use for forcing, size of flowers and length of stem were apparently as good, except lily-of-the-valley flowers, which excelled in size, substance and number of bells.

121. Division is a form of separation in which the parts do not naturally break apart but may be easily torn or cut from the parent plant (rhizomes, tubers, offsets, crowns). Where separation ends and division begins is hard to say, because they blend one into the other.

FIG. 70—BULB "SCOOPING" MACHINE

Used by U. S. Government in Washington State bulb growing.

122. Rhizome, or rootstock, a subterranean stem, especially if uniformly thick, for storage of plant food.

123. Stolon, a slender branch which naturally takes root or bears a bulb at its extremity, where it forms a new plant. It is produced above or below ground.

124. Off-sets are short, lateral branches or stolons produced near the bases of plants to serve in natural propagation. They usually take root and become new plants (houseleek, also known as hen and chickens).

125. Crowns are rooted buds formed usually at the tips of rhizomes or underground stems and at the close

FIG. 71—SWEET POTATO PROPAGATION
1. Dropping and planting "slips." 2. "Slips" as pulled from propagating bed. 3. Fire-heated hotbed.

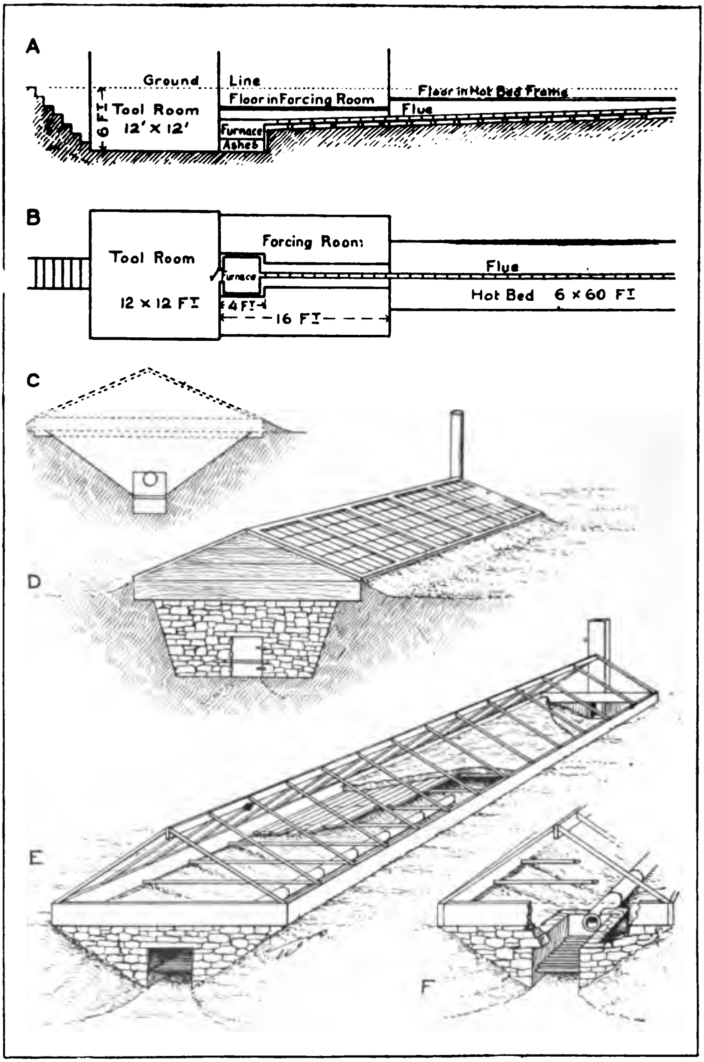

FIG. 72—FIRE-HEATED HOTBED OR SWEET POTATO PLANT STARTER

A, sectional view through side; B, ground plan; C, cross sections; D, general outside view; E, construction; F, detail.

of the growing season of the individual species. Each season they push forward and also develop flowering stems and leaves (May apple, achillea, Solomon's seal, Johnson grass, Bermuda grass, etc.). Lily-of-the-valley is one of the commercially most important crown-bearing plants. Its "pips" are annually imported from Europe by the million to supply the demands of florists. Until needed for forcing, the pips are generally cold stored.

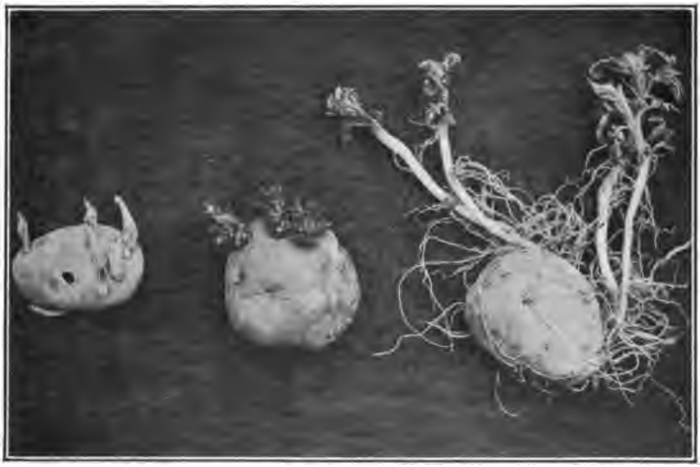

FIG. 73—IRISH POTATOES SPROUTING

At left, tuber sprouting in cellar; middle, one sprouted in full sunlight; right, tuber planted in soil.

126. Rosette, a cluster of leaves or other organs arranged somewhat like the petals of a double rose; for instance, the radical leaves of dandelion and carrot, the stolons of houseleek.

127. Rough division is often practiced when herbaceous perennials grow too thick (phlox, rhubarb, peony, iris) by digging up and cutting the clumps in pieces with a sharp spade. The best pieces are re-planted. Many shrubs (snowball, lilac, barberry) are so treated. This,

the crudest form of division, is little practiced in a commercial way, more in home gardens.

128. Tubers are short, thickened parts of subterranean branches (Irish potato, dahlia) stored with plant food, largely starch, to start new plants at the beginning of the next growing season or other period of stress. Another view is that parent tubers serve as water reservoirs, since experiment has shown that they are heavier after the plant has grown several weeks than before growth starts, due to accumulation of water during plant growth. Often thickened roots (sweet potato) are popularly classed with tubers. Botanically the distinction is that true tubers have "eyes" or buds, whereas thickened roots do not. In practice, true tubers (Irish potato) are often used for making cuttings, whereas thickened roots (sweet potato) are generally planted whole, either direct in the field or in hotbeds (Figs. 72, 80), and sprouts taken from them for transplanting.

When tubers are planted whole, just as broken from the parent plant, the process is called division; but when cut in pieces, each bearing one or more eyes, it is called cuttage (138). From the eyes shoots are developed. Roots form at the bases of these shoots (Fig. 73), not from the tuber itself. As growth progresses special stems are produced above the roots and swell into new tubers.

Tubers are most frequently found in arid climates, but are by no means rare in moist ones. Like bulbs, some are hardy, some tender. Hardy species (Jerusalem artichoke) do best left in the open ground until spring; tender ones (dahlia, potato) must be dug in fall and stored in a cool place not too dry nor too moist, otherwise they will either shrivel or mold.

When true tubers are cut (dahlia) each piece must have at least one bud, because such tubers do not produce adventitious buds, but when thickened roots (sweet potato) are cut and placed in a propagating bed, adventitious buds develop and produce stems. Roots almost never grow from the tubers or the cuttings themselves, but from the bases of sprouts. The shoots may, therefore, be removed and planted separately, as is almost always done with sweet potato and often in increasing stock of new varieties of Irish potato. Other shoots soon develop from the tubers, and the process may be repeated several times. Pseudo-bulbs of orchids are similarly handled.

129. Hastening growth of potatoes may be done in three ways summarized by the Rhode Island Station as the result of experiments thus: a, by planting sets in pots in greenhouses and transplanting

to open ground; b, by "sprouting"—that is, planting sets thickly in cold frames, and when ready to "break ground" transplanting them to the field, etc.; c, by "budding"—that is, subjecting seed tubers the size of hens' eggs from four to six or more weeks to the action of moderate heat and light so one or two strong buds of a dark color and ready to develop leaves and roots are formed on each tuber, while all other buds remain practically dormant. Budded seed tubers, compared with dormant ones, in 89 days from planting gave an increase of nearly 22 bushels of merchantable potatoes and a gain in total yield of 32 1-3 bushels an acre. Compared in 111 days they gave an increase of 41 bushels of merchantable potatoes and a total gain in yield of 54 2-3 bushels an acre. For budding, seed tubers of one to three ounces are to be preferred. They may be "greened" by exposure to light on ground free from vegetation, directly after digging, and placed in trays at any convenient time during winter.

130. Germinating seed potatoes in boxes in Scotland has given an average of nearly 1,100 pounds an acre gain in crop. Potato tubers partially dried are also said to make more productive plants than those not dried.

131. Sweet potato propagation.—Sweet potatoes develop new stems from adventitious buds which appear anywhere on the surface. Usually they are propagated by being split lengthwise in early spring and laid flat side downward in a mild hotbed filled with light soil or sand. The "slips" or sprouts are carefully pulled when four to six inches long and transplanted in the field. New varieties of Irish potato are often propagated in this way and also by stem cuttings so produced (166).

CHAPTER VII

BOTTOM HEAT

132. Bottom heat is the heat applied beneath the growing plants by means of fermenting material (manure, spent tan bark, brewers' grains, etc.) by warm flues, hot water or steam. It is used more or less for all kinds of seeds started in advance of the outdoor season, especially for those of warm climate plants, but only seeds of certain tropical plants require high heat to germinate. Most garden seeds do not need bottom heat, though many sprout quicker if warmed from below; always when bottom heat is used the seedlings should be removed to cooler places very soon or they will become "leggy"; i. e., tall, spindling, and weak. Good ventilation by day will help make them "stocky" and strong.

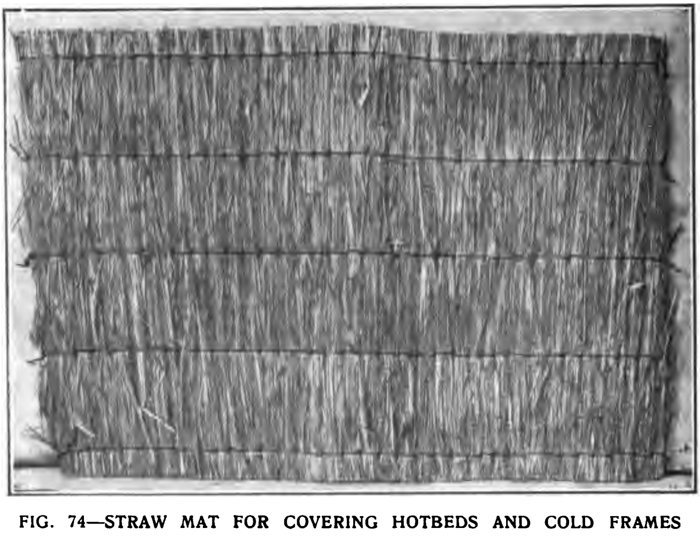

FIG. 74—STRAW MAT FOR COVERING HOTBEDS AND COLD FRAMES

The expression "ten degrees of bottom heat" means that the bed should be that many degrees warmer than the air just above the bed or in the propagating house. Usually, however, the temperature of the bed is indicated, as 60, 70, or some other degree.

133. Natural bottom heat obtained from the sun during the day is of importance at all times, but is scarcely considered in greenhouse winter work, except as something to offset heat from the pipes in the propagating house. In hotbed, cold frame and other structures not usually

FIG. 75—MAKING A CONCRETE HOTBED

The trenches being dug were later filled with concrete without "forms." After the concrete had "set" the earth was taken out, partly by horse scoop, partly by hand.

heated artificially it is of great importance, especially in spring. During the day the sun penetrates the surface layer of soil, which becomes warm. During the night this heat is given off slowly and checked by mats (Fig. 74)and shutters (Fig. 48), so the fullest use may be made of it. The depth to which the soil may thus be warmed depends upon the intensity of the light, the color and other characters of the soil; for instance, dark soils absorb more rapidly than light ones.

134. Application of bottom heat may be obtained in any of the following ways:

1. Hotbeds (Fig. 80) in which manure, tan bark,

brewers' grains, spent hops, or other fermenting material is used, as a source of heat. Fresh horse manure is the most popular of such materials.

2. By horizontal brick or tile flues which carry the gases of fires beneath the benches of a greenhouse or of a hotbed. This method of warming greenhouses is practically obsolete, but for hotbeds, especially for propagat-

FIG. 76—"SWEAT BOX" FOR PROPAGATING
High temperature and humidity secured by closing top and lowering burlap curtains below.

ing sweet potato plants (Fig. 72), it is very popular in Delaware, Maryland and more southern states.

3. Hot water and steam in iron pipes (Fig. 77) are by far the most popular commercial methods of heating because of their ready adaptability to any sized house.

4. Confining air and heat above the cutting bed by means of glass sash over hotbed-like frames on the

greenhouse benches. (Fig. 76.) When necessary to intensify the heat the space beneath the bench is walled in tightly to confine the heat. In a small way bell glasses and similar utensils (Fig. 32) are placed over seeds, seedlings or cuttings on the benches or merely over a soup plate or a saucer filled with sand which covers the cuttings. Sun heat alone is often used in such cases.

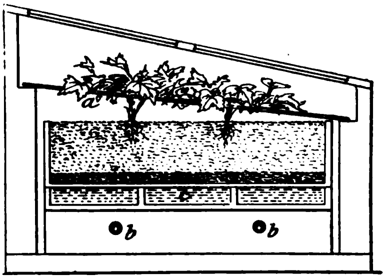

FIG. 77—PIPE-WARMED HOTBED
a, plant support; b, hot-water pipes; c, water tanks.

5. Propagating ovens (Figs. 36, 37) are sometimes used for small lots of seeds or cuttings, as in schools where teaching the principles of plant culture rather than commercial work is the aim, where the room temperature falls low during the night and where there are no greenhouse facilities.

They are generally heated by lamps and are usually more or less insulated boxes with only three to five cubic feet content. In the bottom is a chamber for a kerosene lamp reached by a door for filling and other attention. Above the lamp is a galvanized iron water tray and above this a perforated floor. Next above is the sand tray in which the cuttings are placed for propagation. The cover is of glass. By means of the lamp the water is made to give off vapor which keeps sand and air above it warm and moist. Regulation of the size of the flame and of the ventilators will control both temperature and humidity in the propagating chamber.

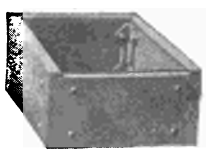

FIG. 78—SINGLE LIGHT MELON FRAME

135. Bottom and air heat effects. All growth in plants results from a stimulus of some kind. Various agents may bring it about; for instance, ether vapor. So far, however, as the commercial plant propagator is con-

cerned heat is the only important one. For though all these agents produce the same effect (arousing the activity of enzymes or ferments, chemically or physically, to change and make available the stored plant food, especially that near the buds), heat is the most active, most normal, and most easily and economically applied. Therefore, the plant grower, while interested in the abnormal agents, applies heat under proper control to secure a healthy growth where he knows it is needed first of all.

FIG. 79—ONE "LIGHT" FORCING FRAME
The sash lifts for ventilation

Cuttings after being set in the propagating bed always begin to grow at the part most favorably placed as to temperature. That is, if a stem cutting be placed so its upper end is in an air temperature appreciably higher than that of the soil, growth will begin in the upper buds. With no cuttings is this so apparent as with cuttings of immature wood, grown in a greenhouse. When bottom heat is lacking and the air warmed, even only by sun heat, the buds expand into new stems and leaves; but few or usually no roots are produced. Such conditions

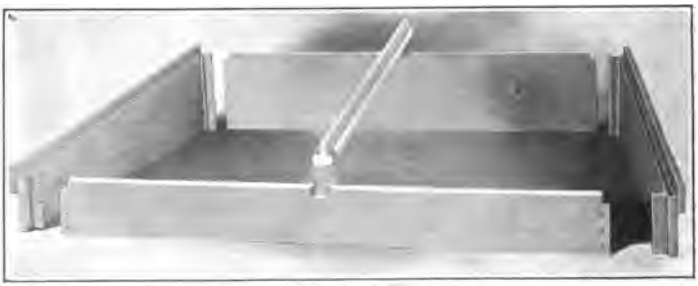

FIG. 80—HOTBED "KNOCKED DOWN" TO SHOW CONSTRUCTION

must be avoided, because the reverse are necessary to root making, which should always, except perhaps with tuber and root cuttings, precede growth of stem and leaf.

The philosophy of this is apparent; for when growth starts, the foods stored in the plant are moved rapidly to the part that has become active. Hence if the part be above ground all the food goes there; in fact, is removed from the part that should form roots. Result, breakdown and death. Conversely, if the air be cool and the soil sufficiently warm from start to finish the cuttings soon develop calluses and roots (Fig. 91) upon which top growth normally depends. Hence such conditions should be maintained, because if cuttings are properly planted growth will occur only below ground, where it should be. When once the roots have begun to grow below ground plant food materials can be taken up by the roots and transferred to the parts above ground. As soon as green matter has been developed by the expanding buds (already present in green wood and leaf cuttings) it can work over the crude food in the presence of sunlight and the full functions of plant growth will have started properly above and below ground.

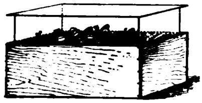

FIG. 81
GLASS COVERED CUTTING FRAME.

FIG. 82—SWEET POTATOES AND VINE

Mature wood cuttings can stand greater hard-

ships in propagating before making roots than can immature wood cuttings, because they contain considerable stored food, but even they should not be started in warm air and cool soil. With green wood cuttings, root growth must always precede leaf and stem growth or death will almost always result.

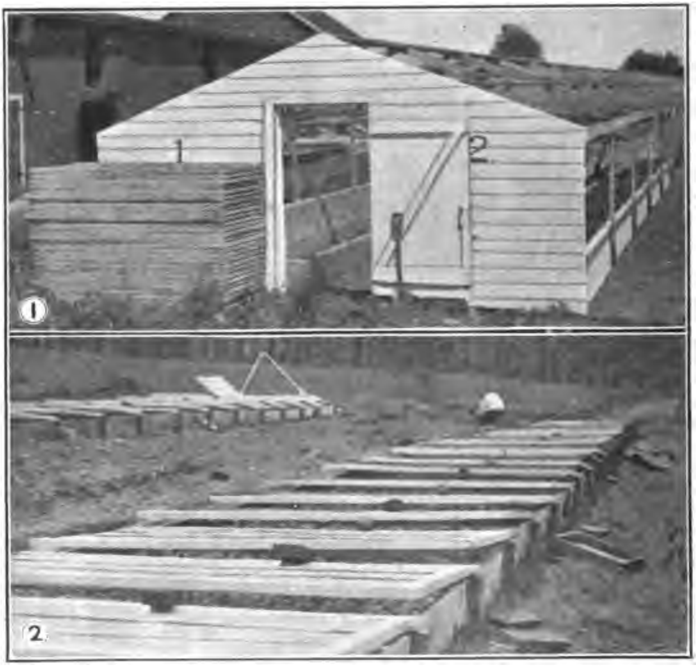

FIG. 83—TWO STYLES OF COLD FRAMES

1. Concrete walls around beds covered with sash on wooden framework. 2. Board frames on ground for temporary use.

136. Hotbed making. In making a hotbed a pit one to two feet deep, six feet wide and any desired length (preferably a multiple of three feet, because standard hotbed sashes are 3 x 6 feet) is excavated and filled with

the freshest possible horse manure that has not been exposed to the weather. Should the manure be dry in spots, sufficient water must be added to moisten it, the whole pile worked over at least twice (three times preferred), so the manure may assume a somewhat dry, oily appearance. Then it should be piled. A layer of less than six inches in the bed will usually give poor results; 12 to 18 inches are the usual depths. Then a layer of say four inches of good friable soil is placed on the manure, and lastly a surface inch or so of fibrous compost, which because of its content of thoroughly rotted manure, grass roots, etc., will bake very little after watering. Sifted loam or compost should be used for the seed bed. After the sash are put on the frames the temperature should be allowed to rise very high. After this subsides somewhat seeds may be sown. During the violent heating period a little ventilation should be given. Banking around the outside aids in retaining heat.

FIG. 84—SHIFTING PLANTS

The ball of earth comes out freely when the pot rim is knocked downward as shown.

Hotbeds in the South, and to some extent also in the North, are often made wholly above ground; i. e., without any pit. The quantity of manure needs to be greater for a given locality than when a pit is used because of loss of heat at the sides of the pile. Depth of pit, manure and whether a pit shall or shall not be used depend upon the climate and the season when the bed is made.

137. Fire-fanging is due to various fungi and bacteria working in rather dry manure, which they injure by "burning up" the vegetable matter. To prevent this

trouble, the manure should be decidedly moist if not wet and packed well. Should slight injury occur the pile should be shaken out well, wetted and re-stacked.

FIG. 85—PROPAGATING SHEDS IN FLORIDA NURSERY

Plants started in greenhouses or other beds are moved to the sheds when well rooted.

CHAPTER VIII

CUTTAGE

138. Cuttage is propagation by plant parts—roots, rhizomes, tubers, stems or leaves—cut in pieces with or without buds. These pieces take root and asexually produce new plants of the same variety as the parent plant. It is in general a cheap, quick and handy way to secure large numbers of plants in a given time. But while all plants may perhaps be multiplied by cuttage, there are some which may be more economically handled by other means such as grafting, budding, division, etc.

For instance, certain varieties of apples, pears, plums and peaches readily strike root from cuttings, but the great majority do not; therefore, the pome fruits are largely grafted and the stone fruits budded, the most satisfactory method being chosen in each case. In other words, species differ in the facility with which they may be propagated by cutting, grafting or other method. Nothing but experience with the actual plant can decide the matter.

The term "cuttage" is supposed to refer to cuttings of the stem, except when qualified by the name of some other part used; as tuber cutting, leaf cutting, root cutting. By amateurs stem cuttings are often called "slips."

Cuttage, separation and division blend into one another almost imperceptibly, but in cuttage the parts are severed from the parent before any roots are formed.

Propagation by cuttings is a cheap, convenient and therefore very popular way to secure new plants. Probably all species of plants may be propagated by one or more methods of cuttage, using one or another part, but with annuals, biennials and many perennials some other method (layerage, graftage, seedage, etc.) is often easier and cheaper. Even varieties differ in ability to root.

For instance, when Clothilde Soupert rose was a novelty a certain seedsman bought stock from which to grow new plants for sale. He gave orders to his propagators to secure a certain number of plants,

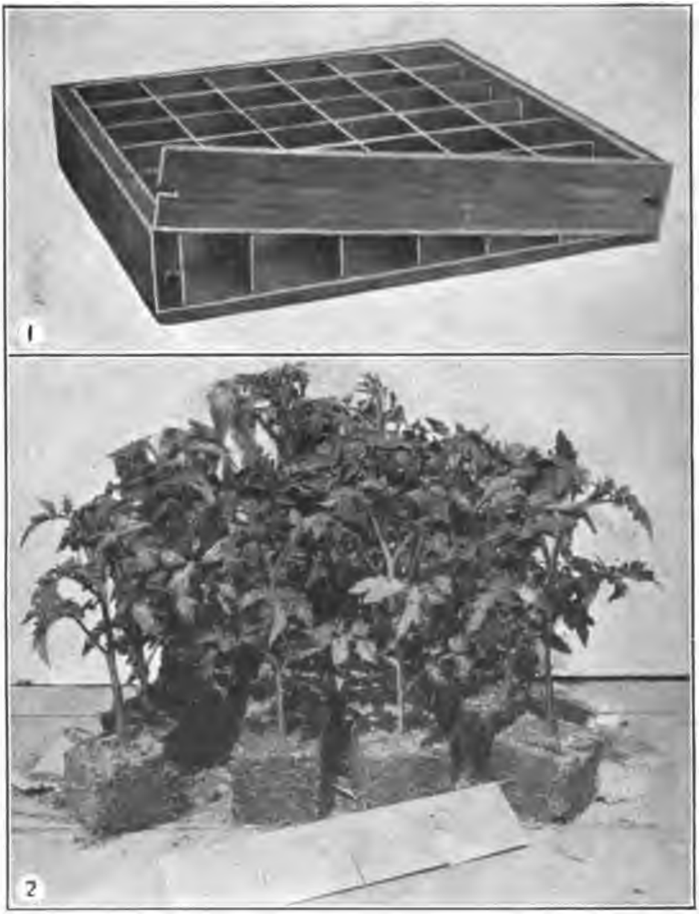

FIG. 86—GARDEN FLAT AND PLANTS GROWN IN IT.

The advantage claimed for this style of flat is that when the cross pieces and the side are removed the plants come out as shown in 2, each with a ball of earth.

if possible. These men, acting upon their experience with roses of the same class, calculated upon what appeared to them a reasonable percentage of loss and made provision for the required space on that

basis. But the variety proved so much easier to propagate than they had thought that thousands more plants were grown than had been ordered. However, as the demand created by good advertising was greater than had been counted upon, practically all were sold and a big profit made. Reverse cases are perhaps more common.

139. Influence of climate on cuttings.—Climate has a noticeable effect upon the rooting of cuttings. In parts of southern Europe and South America, many plants which can hardly be made to strike root elsewhere readily do so. In some of the Gulf states sweet potato vines may be

FIG. 87- STOCK PLANTS OF CROTON

New plants are secured largely by Chinese layers from these plants.

cut in pieces a foot long and thrust into the sand with certainty that they will grow. In Texas hard wood cuttings of quince and persimmon readily take root. Probably in such cases the condition of the soil also has an influence, but since similar soil in similar condition in northern localities does not produce similar results the credit for success must be given to climate.

140. Summer propagation of hardy plants in Minnesota and other western states is difficult because of the dry air. S. B. Green successfully propagated hydrangea, spiræa, barberry, Tartarian honeysuckle, and 11 varieties of roses by stretching burlap over the beds. The strips were not laid horizontally but inclined to the south so the northern edge was at least one foot above the bench, while the southern edge rested directly on the bench. By putting this shade on about nine o'clock and leaving it on till about five the cuttings

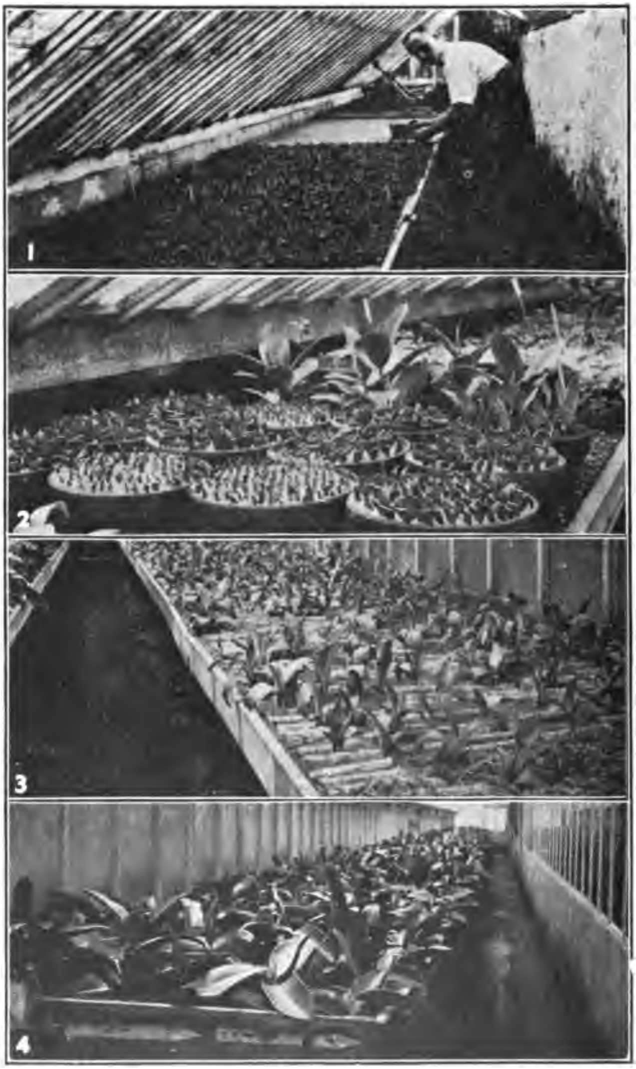

FIG. 88—PROPAGATION BY MEANS OF CUTTINGS

1. Cutting bench with miscellaneous stock. 2, sansevieria cuttings in foreground, rubber plant in middle distance. 3. Dracæna cuttings grown from canes laid on cutting bench. 4. Rubber plants ready to pot from the bench.

were kept from wilting in the driest weather. It was also found that syringing the burlap with water increased the cooling effect, and that comparatively little attention was necessary in watering.

141. Rooting cuttings in dry climates.—Because the relative humidity in dry climates is low, as in parts of the Pacific Coast states, special methods are necessary to make cuttings of certain plants (roses, for instance,) take root. Florists have had good success with the following method: Hotbeds with 18 inches of fresh manure and three inches of sand are covered with glass beneath a frame covered with burlap to provide shade and reduce air circulation. Only one daily watering is usually necessary. At this time, the sashes are raised one at a time to reduce loss of humidity.

FIG. 89—RED RASPBERRY SUCKER PLANTS

Note way new plants develop from roots and the attempts made by the plants to produce new ones.

142. Cuttings require a moist air of proper temperature and sometimes bottom heat (132). This general statement applies with special force to cuttings and growing parts. Heat and humidity must be carefully regulated to suit the species or variety of plant being propagated, because the demands of each vary more or

less. Many devices, some of them very simple, have been adopted for regulating both heat and moisture.

143. Moisture regulation is accomplished usually by propagating frames and boxes of various forms, the commonest being that of a hotbed but smaller. In all the principle is that of confining the air. In a small way a flower pot or a flat may be inverted over the cuttings, (Fig. 32) or a pane of glass (Fig. 32) or a bell jar placed above them. By tilting these more or less the humidity

FIG. 90—METHOD OF POTTING

1. Right hand partially filling soil into pot, left hand seizing rooted cutting. 2. Ready to plant. 3. Filling pot. 4. Finishing.

and the circulation of air may be easily regulated. Whatever is used should admit light in varying degree.

144. Callus, the new formation of cells upon an injured surface; for instance, at the lower end of a stem cutting, or the cut surface of a layer or of a root graft.

145. Stock plants are grown in greenhouses and nurseries merely to supply cuttings, cions, layers, or buds for propagation.

146. "Blind eyes" are shoots which do not produce flowers. They are common on roses and some other

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plants grown under glass. Many propagators think they will produce flowerless plants.

147. **Blind vs. flowering wood.**—L. C. Corbett tested this belief that "blind wood," is inferior to "flower wood" in the propagation of roses. Each year for five years wood was selected respectively from these two classes of shoots to test the cumulative effect of propagation through a series of years. As to rooting ability and growth, little difference was noticed. During the first year the flowering wood plants produce 156 per cent more flowers than plants propagated from blind wood, but during the next two years the percentage decreased instead of increased. The percentage of flowers on the latter also decreased, but not in so great proportion. As a result of these experiments the author concludes that where bloom rather than stock plants is desired, the flowering wood is decidedly the better, but the cumulative effect of propagating roses from one or the other year after year is not marked.

148. **Suckers** are leafy shoots produced from adventitious buds on the underground parts of plants.

The term is sometimes applied (1) to aerial roots or holdfasts of orchids and other epiphytal plants and (2) to shoots which sprout from the trunk. Properly, however, these last are water sprouts (149). Suckers often follow injuries by bugs, tools, etc., to the roots, also from weakness or decrepitude in the tree head, or because of excess of plant food at the point whence they arise. All plants that produce them may be easily propagated by cuttings of the producing parts.

For instance, certain kinds of plum and cherry stocks must be carefully handled to prevent sucker formation; but for plant propagation the stools of blackberries, red raspberries, etc., are often severely root pruned by thrusting a sharp spade full depth of the blade into the soil around the plant so as to cut the roots six or eight inches from the stool and again farther out. Every cut piece will produce a plant. Instead of using a spade the stools are often removed and the ground deeply cut with a disk harrow run in two directions at right angles across the field. See Root Cuttings (162).

149. **Water sprouts** are shoots or limbs of one season's growth produced from latent or adventitious buds on trunks and branches of well-established trees, mainly near where limbs have been removed. See Suckers (148).

both water sprouts and suckers commonly follow over-pruning. They show an undesirable loss of balance between root system and top. In cold climates water sprouts often winterkill. Therefore, they are best removed promptly and with clean cuts. Where practical, careful root pruning will tend to overcome this condition.

150. Origin of roots in cuttings.—In making stem cuttings the usual practice is to "cut to a node"; i. e., stems are cut just below buds. The reason for this is that with most plants a larger proportion of cuttings will "strike root" than if the cuts are made farther away from the nodes. True buds of themselves, however, exercise no influence in the production of roots, for if buried in the earth or other medium, they do not grow. The reason roots form best near the nodes is believed to be that stem tissues at such points are richer in plant food stored there to assist the bud should it start growth. While many stems made into cuttings will root at any point, it is a rule that roots arise most freely at or very near the bases of the cuttings, whether "cut to a node" or not.

FIG. 91—FORMATION OF ROOTS

1. Grape cuttings showing callus. 2. Others showing roots.

Root origin is always in adventitious buds, usually formed beneath the bark or the callus, but always in the primary (meristematic) tissue, the center of the cambium layer. This tissue is composed of undifferentiated cells. Adventitious buds may develop in any part of a plant

where there is an epidermis with primary tissue beneath. The change which leads to the formation of adventitious buds always follows an unusual condition of plant growth

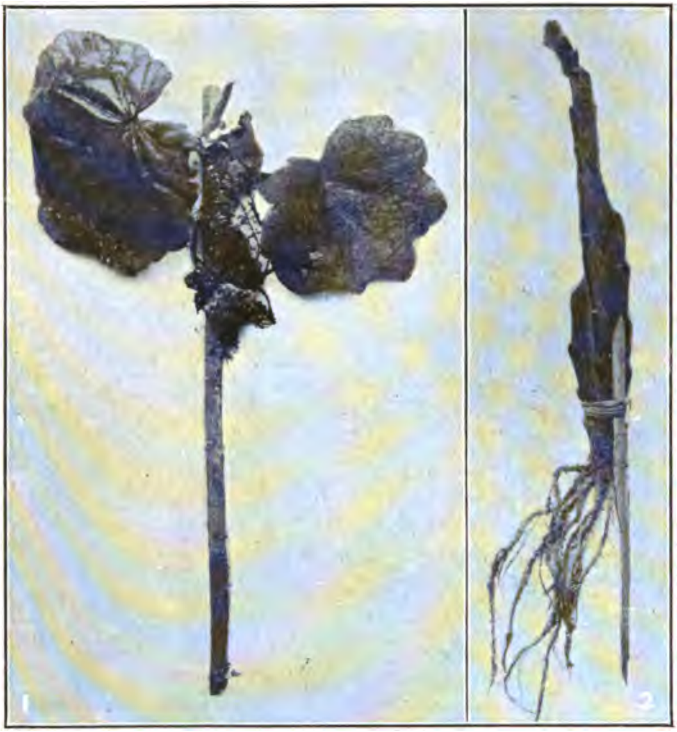

FIG. 92—ODD WAYS OF STARTING CUTTINGS
1. Short geranium cutting rooted. 2. Cactus cutting rooted. Both cuttings fastened to toothpicks.

such as insufficient assimilation of elaborated food by the plant or an injury of some kind.

Thus adventitious buds may be called emergency buds, because they seek to preserve the plant when endangered. This provision of nature has given rise to many of the

asexual methods of plant propagation (cuttings, layers, etc.). Buds formed at the bases of stem cuttings readily push through the callus, but often roots push through the epidermis, even high above this point.

151. Buds are of two general kinds, true or normal and adventitious. A true bud, sometimes called a "brood body," is a growing point in normal position on a stem. It may develop into leaf, flower branch, cluster of leaves, or of flowers, or of both leaves and flowers.

152. Adventitious buds are developed at unexpected points from certain cells in the cambium layer in roots, stems, or leaves. Under favorable conditions any of these

FIG. 93—PACKING FOR SHIPMENT
1. Mail order method. 2. Express package.

cells may develop buds which may develop into either roots or sprouts, according to their position or the necessity of the case. Familiar examples on roots are red raspberry and blackberry; on stems, pome and stone fruits; on leaves, bryophyllum.

153. Leaf buds are undeveloped branches bearing rudimentary leaves specially modified for protection. They develop into branches, which under favorable conditions

FIG. 94—TILE BOTTOMED GREENHOUSE BENCH

This is one of the best styles of bench bottom—because so well drained and so lasting.

of growth, mature other buds in the axils of the leaves and usually one or more at the extremities. Flower buds develop one flower or several, with or without leaves. As to position, buds are lateral, axillary, etc.

154. Latent buds are normal buds in normal positions but dormant beyond the usual time (a month, a year or more). They are called into growth by some peculiar stimulus. Many of the buds on the lower third or more of the annual growth of trees and shrubs become latent during the second year but start growing if the upper

part is cut off. *Lateral buds* are situated on the sides of branches, usually in the axils of the leaves. *A terminal bud* is situated at the extremity of a branch or stem. Usually only one is in this position, but sometimes (lilac) there are two or even more. *Axillary buds* are produced in the axils of leaves.

155. Roots on stem cuttings form on the end normally nearest the root of the parent plant. Stems appear on the other end. Botanists call this phenomenon polarity. With root cuttings the plan holds good; the end normally nearest the top of the plant will produce a stem, and that farthest away, roots. Some species may be compelled to take root when reversed but growth is puny and of short life. If horse-radish cuttings are inverted, they will start late, roots from the "root" end and stems from the "stem" end, but the resulting roots will be small, irregular and unsalable. Hence horse-radish growers generally cut the upper ends of their cuttings square across, and the lower ends oblique so the planters may see which end should be placed uppermost.

156. Shipping cuttings and plants. Plants require fresh air just as animals do. If seeds, bulbs and plants are packed moist in air-tight boxes, they may be asphyxiated or may perish through putrefaction. Growing plants will live a considerable time without light if they can get fresh air and if light and air are good they will stand a rather wide range of temperature. The best method to pack many plants is to knock them out of their pots and roll the earth balls in oiled paper, tied above and below. They may then be packed tightly and upright with a little wet moss between the balls in wooden boxes deep enough to protect the tops. Across the tops of the balls between the rows, strips of batten should be placed and nailed through the sides of the boxes. Perforated zinc on top of the boxes held down by battens may be placed for long-distance shipments. Finally the boxes should be labeled "Living plants. Keep cool. This side up."

If to be sent by sea, the further caution is necessary "Keep away from salt water." Plants so packed may be sent half around the world. On arrival, especially if dry, they should be soaked, root and top, for a day or two before being planted. If woody plants are badly dried they may be buried in moist earth for a week to a month with fair prospects of reviving.

157. Media used for rooting cuttings have great influence upon the regulation of both moisture and temperature, especially the former. They should be porous so excess water will readily drain away; second, be retentive of capillary water so there will always be moisture enough to supply the cuttings with all they need while callusing and making roots; third, they must not bake or crust after watering. For outdoor work a well-drained light, sandy loam of moderate richness usually gives best results; heavy soil and muck poorest. For indoor use, sphagnum moss, cocoanut fiber and specially prepared soils are all used to some extent, but the great material is river or builders' sand. The grade used should be sharp, clean and as free as possible from organic matter. If the greater portion will pass through a sieve of eight meshes to the inch, but not through one of say 25, the range will be about right. Some propagators prefer sand near the coarse limit of this range, some near the fine limit. To prevent damping-off (78) and other troubles the sand should either be sterilized (80) or freshly dug from a deep pit so as to be as free as possible from organic matter.

FIG. 95—DOUBLE POT OF CUTTINGS

Whatever material is used the container must be well drained. When cutting benches have bottoms of small

tile (Fig. 94), enough drainage is provided between the tiles; but with wooden benches it is often necessary to bore holes in the boards and to protect these with pieces of flower pot or to stuff sphagnum moss loosely into them and the larger cracks between the boards. Otherwise too much sand will wash down and be lost and the cuttings may suffer.

For best results, water in media for rooting cuttings, as in soil for crops, should be in the form of thin films around soil or sand particles. The finer the particles the larger the quantity of water that may be held and usually the harder will the soil pack—both undesirable in a cutting bed. The familiar example to illustrate the former point is of a cube. This has six sides, but cut in half the bulk has not been increased though two new surfaces have been added and the possible film area thus increased one-third. Repeated sub-division thus increases the surface area without increasing the bulk. Hence the high water-holding capacity of fine sand and soil.

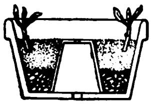

FIG. 96—VENTILATED CUTTING POT

158. Double pots are often used for small lots of cuttings because of their convenience (Fig. 95). In a large pot is placed a liberal handful of "crocks" (91), clinkers or other drainage material. Sand is added to a depth sufficient to admit a small pot set upon it so the rims of both pots are on a level. The drainage hole of the smaller pot is plugged so no water can escape, except by seepage through the sides or by evaporation. After adjusting the smaller, sand is placed between the two pots, the smaller filled with water and cuttings stuck in the sand for rooting. The water in the little reservoir seeps out and keeps the sand moist but never too wet for the cuttings. Scarcely more attention is needed than to keep the little pot full of water.

159. Shading, especially of newly made greenwood and leaf cuttings, is essential to success because the moisture

in the cuttings themselves must not be greatly depleted. This would be the case were all the leaf surface allowed to remain or that retained exposed to free circulation of air, moist though that of the propagating house may be. The usual plan is to cover cuttings or frames containing them with newspaper (Fig. 18). Factory cotton and cheesecloth are also used more or less (Fig. 15). These materials are all placed where the sun strikes the beds.

160. **Screens for seedlings** are perhaps best made by a picket machine which binds builders' lath with woven strands of wire. These screens are quicker made, cheaper, more flexible, durable and easier handled than those nailed together.

FIG. 97—NURSERY BEDS

1. Hand forking the soil is generally necessary because the beds are narrow. 2. Right and wrong method of weeding. The man on the right has his foot in the bed.

CHAPTER IX

CLASSES OF CUTTINGS

161. Plant parts to use.—Cuttings may be made from any plant part that has a primary tissue (meristem). They may be divided into four groups, dependent upon the parts used: 1, Roots; 2, root-stocks and tubers; 3, stems; 4, leaves. As in all other kinds of asexual propagation, cuttings reproduce the same variety as the parent plants from which taken, bud variations or "sports" excepted.

162. Root cuttings may be made from true roots of any plant species which naturally produce suckers (osage, orange, poplar, willow, red raspberry, trumpet creeper, dracæna, horse-radish, plumbago, bouvardia). The roots are cut in pieces usually three inches long, either stored in moist moss or sawdust or placed directly in the propagating bed. With most cool climate plants the rooting is done out of doors without artificial heat; with warm climate subjects bottom heat in greenhouse or hotbed is required. Plants in the former group are often handled with bottom heat to get best results or shorten time.

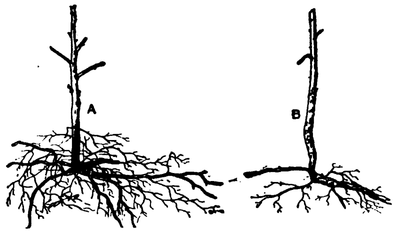

FIG. 98—BLACKBERRY PLANTS

A, root-cutting plant; B, sucker plant.

Blackberries and red raspberries, especially when stock is scarce, are often increased commercially by root cuttings (Fig 98). Roots one-fourth inch or even smaller in diameter are dug in fall, cut in pieces one to three inches long, packed in green sawdust or moist sand, stored in a cold but frost proof cellar till spring and the callused ones then planted like peas, not closer than an inch asunder in furrows wide enough apart for horse cultivation. They make salable plants by fall. When an extra demand

is expected the cuttings are sometimes started in heated propagating beds in fall so plants may be ready for sale in spring. In the South they are often made in spring and planted in the open.

Pear, apple, cherry and peach root cuttings may be grown in frames with bottom heat, but this method has never been very popular with nurserymen because graftage (192) is considered more economical.

Root cuttings are open to the objection that they do not always transmit variegation though they do perpetuate the variety otherwise. It must also be remembered that the root will propagate *its* variety; that is, if roots of a grafted plant be selected, those taken from below the union will produce "seedling-stock" plants, while those above that point will grow plants of the cion variety.

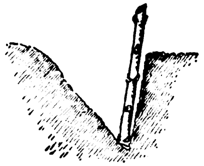

FIG. 99—CUTTING READY FOR BURYING

163. A sport or bud variation is a plant or plant part, as a twig, which unexpectedly shows a character different from that of the variety or species or the balance of the plant. Usually this character cannot be reproduced by seed but is almost always propagated asexually. Even then it is still called a sport. The term is not commonly applied to monstrosities or deformities, but to more or less attractive and apparently normal characters, as doubling of flowers on single-flowered plants, variegation and other changes of the color on green plants, etc. Bud variations may be the starting point of new varieties or of reversions to earlier forms.

1C4. Tubers and tuber cuttings, because of their food content, can live long after growth starts before the new plants may be able to take food from the soil. In potato plant formation the eye sends a shoot through the soil to air and light. Then roots begin to form near the base of the shoot. These roots secure food though the plantlet continues to draw upon the food stored in the tuber. In

time special shoots emerge from the stems, extend short distances and later thicken to form tubers. For commercial planting, Irish potato tubers are usually cut in pieces, each containing at least one eye or bud. If cut through an eye each half eye may produce a shoot and be somewhat earlier than the other eyes in the same piece. Cuttings are often slightly dried and allowed to sprout in the light, which produces short purple shoots (Fig. 73)

FIG. 100—TRANSPLANTING MACHINE IN OPERATION

The boys place plants alternately between a pair of jaws which open at regulated intervals, close and set the plants in the soil. Each plant may be watered at the same time.

that develop more rapidly than do unsprouted eyes. They apparently do not rob the tubers of plant food as do the white shoots formed in the dark.

Irish potato tuber cuttings, each piece including at least one "eye," are dropped in the ground and allowed to take their course. Much discussion has arisen as to the proper size of piece. Experiment in many states and under numerous soil and other cultural conditions seems to favor moderate-sized tubers and cuttings rather than over-sized ones and single eye pieces.

Since the sweet potato is a true root and therefore without buds it produces sprouts from adventitious buds most abundantly, as a rule, at the stem end. The shoots take root as do those of Irish potato, but roots may also develop from the potato itself. The sprouts are "slipped" off with roots attached and planted in rows by hand or with transplanting machines (Fig. 100). Should they not have roots at the time of planting, they soon overcome this apparent handicap in favorable soil. Sweet potato propagating beds are either mildly warmed manure hotbeds or heated by flues (Fig. 72) in permanent beds.

FIG. 101—CARNATION CUTTINGS

1. Newly made.
2. Rooted

Stem cuttings of certain tuber-bearing plants (potato) do not develop new plants, but tubers either at the bases of cuttings or in the axils of leaves above ground. New plants will develop from these tubers. Leaf cuttings of some kinds also do this.

165. Rhizome cuttings, made from underground stems (achillea, canna, rhubarb), are treated like tuber cuttings. Two bad weeds accidentally propagated in this way are quack grass and perennial morning glory (bindweed), every joint of which is capable of producing a new plant.

166. Stem cuttings are of three kinds: 1, dormant, ripe, mature or hardwood; 2, green, immature, soft wood or succulent; and 3, an intermediate class, semi-hardwood.

167. Styles of mature cuttings. Mature wood cuttings may be made of any length, but 6 to 10 inches is the usual range for those with more than one bud. With perhaps the majority of species so propagated, two nodes and one internode

are preferred, though with short-jointed plants such as Delaware grape, currant and plum, several nodes may be used, in which case all but the top bud or buds—those above or at the surface of the soil—are cut or rubbed off to prevent the formation of shoots from below ground. Satisfactory growth of cuttings does not depend on number of buds; single buds in many species give as good results as when several are used. In the cutting bed all long mature wood cuttings are set vertically with a bud or two above the surface.

168. Single eye mature wood cuttings are often made

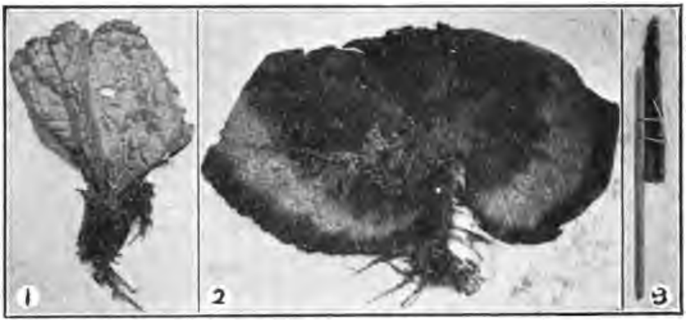

FIG. 102—ODD WAYS OF STARTING PLANTS FROM CUTTINGS

1. Sectional leaf cutting of begonia. 2. "Whole leaf" cutting of begonia. 3. Cactus cutting fastened to toothpick to be kept steady in cutting bench.

when stock is scarce or costly in two popular ways. In the first case the wood is cut half way between nodes, the cuttings laid flat with eyes upward in the cutting bed and covered with an inch or so of soil. In the other style cuts are made, one a little above the bud and the other a couple of inches below. These cuttings are thrust vertically in the bed as far down as the buds. In each case the cuttings are generally started with bottom heat under glass about three months before work could be done out of doors. From the start the sand must be kept moist. Shading is often necessary. When the leaves ex-

pand, sprinkling must be frequent to prevent wilting. In four to six weeks the plants may be potted. Species, variety, season and locality, all influence results.

169. Mature wood cuttings may be made at any time. With plants growing in the open the great majority are made for planting in spring. Many of these are cut only a short time before being planted; many more are cut in fall and stored over winter in bundles buried in a well-drained sandy knoll, or stored until spring under cover in moist soil, sand, sawdust or moss.

FIG. 103—GOOSEBERRY CUTTINGS

The chief advantages of the last-named plan are that the bases callus over before planting time and possible winter injury is avoided. Occasionally (currant, gooseberry) cuttings are made as soon as the wood is mature and the leaves begin to fall. They are then callused and fall planted, thus gaining a good deal of time. Winter mulching of fall-set cutting beds is essential to success, because heaving and settling of soil under alternate freezing and thawing break the tender roots.

With short-jointed plants, little care is taken to cut the lower end to a bud, but with long-jointed ones best results follow cutting just below nodes. It has also been noticed that grape cuttings with more than two buds give better root systems than do those with two buds or only one, since roots are developed at each buried node. Only the top bud is left to produce a stem, the others being rubbed off. Long, mature wood cuttings are usually set obliquely in the cutting bed so as not to be too deeply covered. Another advantage of this is that

in poorly drained soil and in cold, wet seasons roots will form better than if cuttings are set vertically. Hence grape cuttings with two buried nodes usually make better plants than those with only one bud buried.

FIG. 104—STUDENTS IN THE PENNSYLVANIA STATE COLLEGE GREENHOUSE

1. Each student has his own bench space where he does "head house" work. 2. In the forcing house each one has his own beds to tend. The boys are working on radishes.

170. **Evergreen mature wood cuttings,** especially of cone-bearing plants (arbor vitæ, juniper and retinospora) are fall planted under cover in sand either in a cool greenhouse or some other cover. Usually they take root slowly, sometimes a full year (yew, juniper), but continue green if properly shaded and watered. After rooting they may remain in the flats till the following season for out-of-door planting or may be potted. The cuttings, usually four or five inches long, are always made of well-ripened wood sometimes two, three or even four years old. The needles or leaves are cut from the lower two-thirds of the stem with a sharp knife. They should never be pulled or rubbed off. Remaining leaves are not covered with soil. Probably all cone-bearing trees may be propagated by cuttings. It is not, however, profitable to grow pine this way; seed is cheaper. Spruce cuttings are very slow to root (12 to 18 months) so fine varieties are generally grafted.

FIG. 105—CALLUSING BED FOR CUTTINGS AND ROOT GRAFTS
In this the bundles of grafts and cuttings are placed in fall or winter for spring planting.

171. **Rose cuttings of dormant wood** are largely used both out of doors and under glass. When to be grown out of doors the cuttings are made about six inches long from mature wood in the fall before severe freezing weather comes. Bundles are stored in sand over winter and planted in spring in V-shaped trenches with only one bud showing. Rich soil produces strong plants in one season. When grown under glass the cuttings are made in November or December and planted in sand in cold frames or cool greenhouses. By February or March they may be potted. When warm weather arrives they are planted in rich soil.

172. **Ringing roses to facilitate cuttings propagation** was done experimentally by Greiner, a French investigator, who found that such cuttings strike root much more readily than do ordinary ones. The stems of the parent plants were ringed in July or August. By November the wounds had callused. The method is recommended for varieties difficult to propagate by ordinary cuttings. Several rings made at proper distances apart to get right-sized cuttings may be made on the same branch.

173. **Cuttings from grafted grapes.**—F. Baco, a French investigator, has proved that with certain varieties of grapes used as cions,

grafting not only causes specific variations but that these variations may be perpetuated by cuttings. Variations in the vegetative parts also seem to be accompanied by variations in the root system.

174. Browning of grape cuttings is due to bacteria and is considered a disease, but P. Viala and L. Ravaz, French investigators, say it is without pathological effect. Externally the cuttings retain their normal color and when grafted readily make unions. They root well and produce vigorous branches. The bacteria are never found in the new growth no matter how abundant in the cuttings, nor do they descend into the stock in case of grafting.

175. Dwarf plants from cuttings.—In France cuttings taken from the tips of branches of plants which have reached full development but have not produced flowers, will take root under proper conditions and produce flowers without much further growth. If the

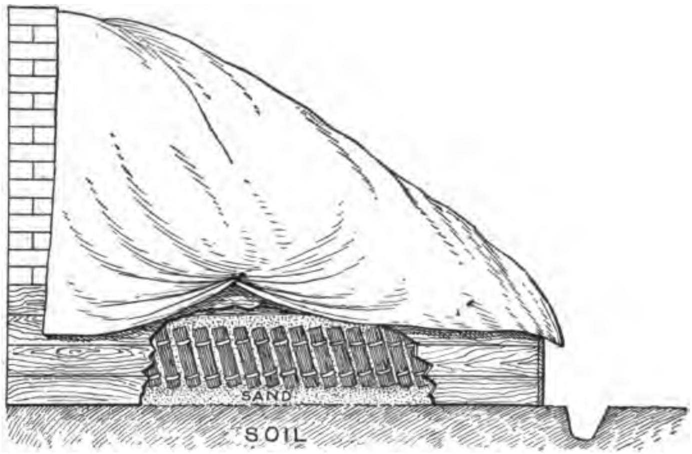

FIG. 106—PLAN OF CALLUSING BED

Notice the position of the bundles. They form calluses best when set upright.

plants to be dwarfed produce both terminal and axillary flowers, the cuttings should be taken from the least-developed flower branches. The cuttings should be made about an inch under a node in each case. Chrysanthemums, asters, roses, and several greenhouse plants have been thus dwarfed.

176. Callus pits (Fig. 106) are excavations in which cuttings are buried for a few weeks or months prior to planting. They must be made on well-drained knolls fully exposed to the sun so the greatest possible use may

be made of natural bottom heat. For short periods in fall and spring, bundles of cuttings are buried upright with their butt ends upward to hasten callusing. Depth will be governed by length of cuttings and season; a covering of two to six inches of sand or friable soil is enough. Because the upper ends of cuttings are placed downward the buds are kept cooler than the butt ends

FIG. 107—STAND FOR MAKING GRAFT AND CUTTING BUNDLES

The tier around each stem shows where the graft has been made. When the rack is full the loose raffia is brought up and tied around the bundle.

and, therefore, do not sprout even under fairly favorable conditions for starting growth.

Fall-callused cuttings may be dug up and stored in cellars over winter. Fresh hardwood sawdust from green wood is considered the best material in which to store mature wood cuttings because it has just the right humidity and retains moisture so well; watering is rarely necessary. The storage room must be kept cold but above freezing point. If warm the packing material may dry out rapidly. Watering may cause cuttings to heat

and sprout long before they could be planted in spring. Hence there would be loss.

177. Burying hardwood cuttings bottom end upwards from a few days to a few weeks in spring before setting in the cutting bed takes advantage of heat in the upper layers of soil. It is of particular advantage with cuttings slow to take root; for instance, certain varieties of grapes, such as Norton and Delaware. Usually, for convenience in handling, the cuttings are tied in bundles (Fig. 107) of

FIG. 108—ROOT AND BULB STORAGE CELLAR ON A HILLSIDE

Shelves are used for such plants as cannas, dahlias, gladiolus, placed in boxes. Potatoes and other roots are generally stored in piles or bins.

100 and buried tops downward in a sandy knoll fully exposed to the sun and only two or three inches deep. Often frames are used (Fig. 106). Sometimes cuttings are so treated in fall and taken up for cellar storage when the ground begins to freeze hard; sometimes they are stored without this previous treatment, but buried in spring for a few weeks before planting. Hardwood cuttings grown out of doors do best when of medium (six or eight inches) rather than extreme length because they are warmer from the natural bottom heat.

178. Semi-hardwood cuttings, those of nearly mature but still green wood, are used to propagate many hard-

FIG. 109—POTTING
1. Placing the drainage in the pot. 2. Placing the rooted cutting and the soil. 3. Firming the plant in the pot.

wood trees, shrubs and vines such as rose, lilac, diervilla and hydrangea. For outdoor work they are made usually before midsummer; indoors, during late winter. They are cut and treated about the same as are hardwood cuttings. Frequently they are secured in summer after the buds have developed and the wood is nearly mature. Two to five buds are usually allowed. The cuttings are set only a couple of inches deep at most in frames sheltered from sun and wind. Until the roots have formed they are kept closely covered and are often sprinkled to keep the air about them humid.

179. Grape cutting storage experiment.—A bundle of grape cuttings was placed in dust as soon as made, another in sand, a third half in sand, and a fourth in the same cellar but without protection. In spring when planted in the nursery, best results were secured with the dust-stored cions, next best with those in sand and poorest with those left uncovered—only about 20 per cent of dust-stored cions.

180. "June-struck cuttings" are made from the young shoots of various hardy shrubs such as privet, weigela and hydrangea. The two to three-inch cuttings partly stripped of their leaves are started under glass. They must be very carefully shaded

and watered. Rooting is rather slow, a month or more often being necessary. Good plants may thus be grown, plants which after wintering in cold frames, may be set in the open the following spring. This is a quick method of increasing stock, since more or less cuttings of green wood may be made from the plants in the latter part of the season and grown indoors during the winter.

181. Transplanting outdoor grown cuttings should occur at the close of the growing season, if there is time between the ripening of their wood and the approach of winter for them to become established. In such cases

FIG. 110—FIELD PLANTING OF POTTED DAHLIAS
1. Italian laborer who sets 4,500 plants in 10 hours. 2. Gang of men he leads.

winter mulching is necessary. When maturity is late, spring planting is advisable. Always liberal space should be given so the plants will have ample food and develop symmetrically. In some cases, plants may be sold at one year old; in others, at two years.

Cutting plants should never be allowed to remain in the nursery rows more than one growing season. If they are there will be serious loss of roots when dug.

182. Green wood or soft wood cuttings are more widely used than any other kind because they strike root easily, are readily rooted under glass and the great majority of plants, whether soft or hard wooded, can be propagated

by them. In amateur window gardening they are often called "slips," because they are the side shoots pulled or "slipped" off the main stems and branches of plants. The term is not used in commercial practice since "cutting" covers the whole idea. Bedding plants—alternanthera, achyranthes, coleus, geranium (Fig. 92), verbena, ageratum, and salvia—are so propagated. Green wood cuttings are also made of dahlia, sweet or Irish potato sprouts when stock is costly or scarce, tubers being started in the usual way, the stems cut when large enough, and placed in a cutting bed. Soft growing tips of many ornamental shrubs and other hardwood plants are treated thus at the right stage of development.

FIG. 111—GREEN WOOD FOR CUTTINGS
a, just right; b, too old.

183. Requisites for green wood cuttings.—The primary requisite for success with green wood cuttings is vigorous health in the parent plant. Failure is almost certain otherwise. Second, when bent the wood must be in such condition that it will not crush but snap, leaving a clean break across the stem with nothing but a little epidermis connecting the broken part with the stem below (Fig. 111). This is a beginner's test; experienced propagators recognize the right stage of development at a glance.

184. Stem parts used for green cuttings.—Propagators dispute whether terminal or twig tip cuttings will give better results than those lower down. Doubtless cuttings made from main stems and each with a terminal bud will give most satisfactory results, but this is rather because of their vigor and vitality than because of the

mere presence of terminal buds. Therefore, when there is a good supply of plant material, propagators usually gather only the tips of the shoots (Fig. 111) for making green wood cuttings. Especially is this the case with bedding plants that have been growing in the open air. Such plants are either transplanted to the greenhouse or cut close to the ground and taken to the work room, where terminal growths are made into cuttings and the balance thrown away. During the winter stock plants (145), as also the first rooted cutting plants made from them, have their terminals removed to make new shoots. Such plants often produce growths of 3 to 10 inches, depending largely on species and variety. When such growths are cut and propagated by midwinter they produce bedding plants for outdoor setting by spring.

185. Making green wood cuttings.—Green wood cuttings are usually two to four inches long and have at least one leaf. When several leaves are allowed to remain they are cut more or less to reduce transpiration of water. Usually the cuts are made just below the nodes, but with many subjects this is unnecessary, as soft wood cuttings will often strike root at any point covered with soil, though most roots come near the base of the cuttings whether or not cut near a node. When cuttings are very short, they are often tied to toothpicks (Fig. 92) so they will "stay put" in the propagating bed.

186. Removal of leaves from green wood cuttings, as also from transplanted plants, is not essential to success, but is an aid, since it checks transpiration of water and, therefore, the danger of "flagging" or wilting. Entire stripping of leaves as compared with leaf-surface reduction should be avoided, as the assistance of some leaf surface is helpful to root formation, *provided* proper moisture control is practiced. Various subjects do best under various treatments; for example, coleus should be severely stripped, geranium rather less, alternanthera very little.

187. Bedding green wood cuttings.—Since green wood cuttings are usually more easily injured than are those of mature wood, they are handled more carefully. When large quantities of one kind of plant are made the usual practice is to drop them as finished into water to prevent wilting. The propagating bed is prepared by leveling off and soaking the sand. Then a narrow board or "straight edge" is placed across the bed from aisle to

FIG. 112—BUDDING NURSERY STOCK

Notice the tiring position of the budders. This is the usual attitude, though some budders work on their knees.

back and a wooden knife or a large label sharpened on one edge thrust obliquely in the sand (Fig. 43) to the required depth beside the board at the back of the bed and drawn toward the aisle, thus making a trench with a vertical and solid sand wall on one side and an oblique rather loose one on the other. The board is then removed, the cuttings placed at proper intervals against the vertical wall and loose sand from the other side pressed against each with the fingers (Fig. 43). After all are in position the bed is drenched with a fine rose sprinkler to settle the sand. Newspapers are then spread

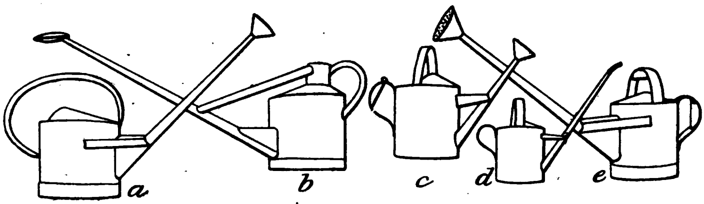

FIG. 113—VARIOUS STYLES OF WATERING POTS

A, adjustable to any position; b, reaches far; c, common style; d, long-necked form without nose; e, common style but with long neck.

over the cuttings (Fig. 18) to check transpiration and evaporation for a week or two. Strong sunshine is very injurious until the cuttings have made roots (Fig. 91), because the stems cannot take up water and because the leaves give off moisture more or less rapidly. Hence the necessity for great care in watering and shading, the former to keep both sand and cuttings moist; the latter to keep the air around the leaves humid.

In a small way green wood cuttings may be started in flower pots, saucers or soup plates two-thirds filled with sand and then kept brimming full of water. Bottom heat, when necessary, may be supplied at the back of the kitchen stove. It is not essential to shade these plates even when set in full sunlight.

Another method of placing "soft wood" cuttings in the sand bed is to press the edge of a window pane vertically

into the sand. Insert the cuttings at proper intervals in the neat trench thus prepared and tighten the sand about them by gently tamping it with a brick or a heavy wooden block (Fig. 20). Lay a thin board, of any desired width, between the rows of cuttings, on the sand with one edge against the preceding row, using the other edge as a guide for the glass. Prepare other trenches similarly. This insures a neat bed with level surface.

FIG. 114—BRYOPHYLLUM LEAF
With young plants in notches of margin.

188. **Tomato cuttings** grown experimentally out of doors have given more, earlier but smaller fruits than seedlings; indoors seedlings were decidedly superior.

189. **Keeping soft cuttings alive for long periods.**—G. W. Oliver has successfully transported herbaceous cuttings from distant places as follows: A layer of cuttings is arranged, upper leaf surface down, without crowding, on a pane of glass and covered

with two or three inches of fine, damp sphagnum moss evenly distributed. A second layer of cuttings is placed on the moss with the upper surfaces of the leaves facing upward and covered with a second pane of glass. The two panes are pressed firmly and made into a package by tying. By keeping the moss moist and giving plenty of light, the cuttings carry well, provided the material is healthy. When the journey is long the cuttings are often rooted on arrival. With the moss only slightly dampened, cions and bud-sticks of rare plants have kept well long under the same treatment.

190. Sugar cane cuttings have been shipped long distances when treated with bordeaux and then packed in damp charcoal.

191. Leaf cuttings.—Leaves of certain plants may be made to produce new plants. Some of these are planted whole, others cut in various ways. In certain cases (rex begonia) the new growth arises from adventitious buds, but in others (various ferns) it comes from true buds which originate in the stems. True buds may form on the leaves before being cut from the parent plant (*Bryophyllum calycinum*) or afterwards (rex begonia); normal in the former case, adventitious in the latter.

FIG. 115—ROOTED GLOXINIA LEAF

Temperature and moisture conditions are the same for leaf cuttings as for soft wood cuttings. While many plants may be made to reproduce by leaf cuttings (cabbage, lemon) few can be profitably so propagated. The process, in some cases, detroys variegation in the progeny; e. g., while certain variegated ivy geraniums may be reproduced by soft wood cuttings, they become plain green when leaf cuttings are used.

In some cases whole leaves are used as cuttings, in others the leaves are cut in pieces. A whole leaf of begonia is placed flat on the propagating bench with a short piece of its petiole buried in the sand. Cuts are then made across the main veins in various places and the leaf either pegged down or held in position with a little

sand. If contact with the sand is good and if moisture and temperature conditions are right, little plants will be produced at the wounds and also where the veins start to branch at the leaf base. When large enough to handle conveniently, they may be potted.

With costly or scarce stock begonia leaves are often cut from their bases outward to the margins, thus forming somewhat fan-shaped or triangular pieces two or three inches long and an inch or so wide. In this case the stalk is cut off close to the leaf blade and the basal third of the blade also cut from one edge to the other by a straight slash. This base is then cut into wedge-shaped pieces with a rib in the middle of each and a small part of the petiole at the lower end. The triangular pieces thus formed are placed stem end down in a cutting bench. Soon young plants form at the lower points (Fig. 102).

Bryophyllum leaves, in greenhouse practice, are laid flat on the propagating bench. Soon they form little plants from most of the notches on their margins (Fig. 114). In Bermuda and other moist climates, such plants will form even when the parent plants or the mature leaves are hung on the walls of a room. The same thing often occurs in greenhouses.

Whole gloxinia leaves are used, the stems being placed in the sand. Unlike the other cases cited, neither stems nor leaves usually take root, but a little tuber forms at the base of each leaf stem. Such tubers are then dried and after a "rest" planted like other tubers. Fig. 115 shows a leaf cutting that did take root, but did not form a tuber. It might have done so if allowed to remain longer in the cutting bench.

Hyacinth leaves placed in a propagating bed soon develop bulblets at their bases. Treatment of these is the same as for those grown by other methods.

CHAPTER X

GRAFTAGE—GENERAL CONSIDERATIONS

192. Graftage, which includes grafting, budding and inarching, is the natural or artificial process of making a part of one plant unite with and grow upon the roots of another. A graft may, therefore, be considered as a cutting which unites some of its tissues with those of another plant or plant part with or without forming either callus or roots, as always happens when cuttings are developed into independent plants.

193. As a horticultural process, graftage is of very ancient origin. In his Natural History (Vol. 2 pp. 477 to 485) Pliny about 2,000 years ago, wrote about it as common practice, but its methods have been kept largely as trade secrets or mysteries until within the last half century or so. Pliny says the art was taught by nature. But he goes too far, for he declares that cherry has been

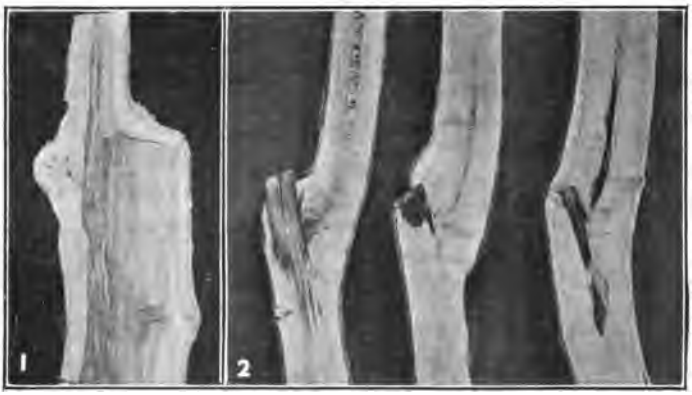

FIG. 116—SECTIONS OF GRAFTS

1. Plum cleft graft. 2. Bud grafts one and three years old. Note old stock wood and continuous layers of young tissue.

found growing on willow, sycamore on laurel, laurel on cherry and so on. Such cases, except as noted (207), are not grafts at all but are merely trees of one kind growing in soil held in crevices of another kind—cases by no means rare.

194. Stock—any plant part, usually root or stem, in which a bud or a cion is inserted to propagate a plant species, variety or strain.

195. Cion—any plant part, usually of a stem, inserted in a stock for propagation. It may consist of one bud with little or no wood, as in budding, or of one or more buds with one or more inter-nodes, as in grafting.

196. Objects of graftage. Graftage may be used: 1, To alter plant character by modifying wood, foliage, or fruit produced. 2, To develop branches, flowers or fruit where they are lacking on trees or shrubs. 3, To enhance

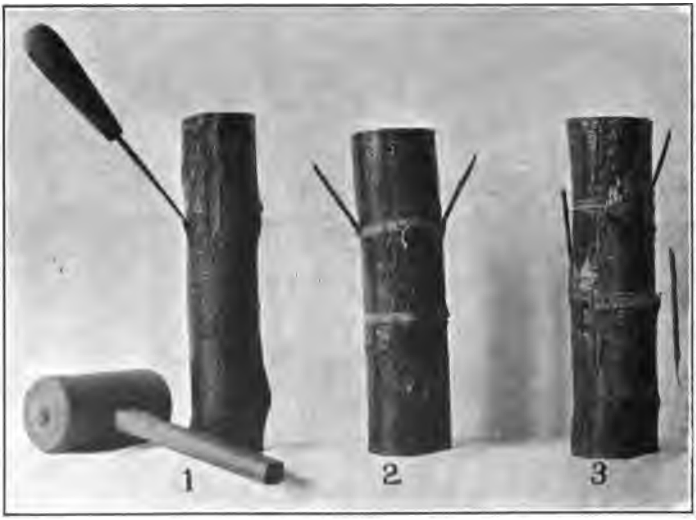

FIG. 117—SIDE GRAFT

1. Stock, chisel and mallet; 2. Incision made and graft wrapped; 3. Waxed, completed graft—cion at right.

the vigor of defective or exhausted trees and shrubs by influx of fresh sap. 4, To facilitate reproduction of monœcious or diœcious plants by grafting in cions of the lacking sex. 5, To propagate and preserve varieties of countless woody and some herbaceous plants which cannot be conveniently reproduced by other means.

197. Necessity for graftage. Since seedage is quicker and cheaper, graftage is rarely employed to propagate species, and then only such species as produce seed sparingly under cultivation are so reproduced. For similar reasons cuttage and layerage are preferred for most shrubs. Graftage finds its chief application, therefore, in the propagation of varieties and strains of woody plants that do not come true from seeds and that cannot be cheaply or conveniently enough grown from cuttings, layers or by other asexual methods. All our named varieties of tree fruits, nuts and many ornamentals such as azaleas and roses (not all roses, by any means) are propagated by one or more methods of graftage. As in other asexual methods, graftage will produce the same variety as the parent tree or shrub, bud sports excepted.

For these reasons graftage is a necessary business process, because nowadays planters demand stock true to a definite standard of quality, size, trueness to type and ability to meet other requirements which can be met, at least among woody and many herbaceous plants, only by asexual means, among which graftage has been proved by commercial nurseries to be the most economical. If this were not so, other methods would be followed; for the nurserymen are human enough to choose the methods that give results most satisfactory to all concerned; otherwise they could not long be in the business. Hence we find pome fruits still largely root-grafted in winter (though budding is gaining in popularity), pit fruits budded in summer, currants grown from spring-set cuttings —each kind of plant propagated by the method that suits it best and most economically gives best results.

FIG. 188—WINTER COURSE STUDENTS MAKING ROOT GRAFTS

Students in all horticultural courses have practice of this kind at the Pennsylvania State College. The picture shows students at the New York State College of Agriculture.

198. Unreliability of seeds.—Graftage of some other asexual process is necessary also because seeds cannot be relied upon to produce varieties of tree and bush fruits or of many shrubs, herbaceous perennials and other plants true to name, the reason being that the type has not been fixed by that method as in the case of many vegetables, annuals and some perennial flowers.

For instance, if seeds of the Northern Spy apple (199) or of Salway peach were sown, all we might be able to say of the young trees grown would be that they were respectively apple and peach trees; possibly not one would resemble the parent enough to deserve the name Northern Spy apple or Salway peach.

The cause of this lies in the fact that from prehistoric time flowers of fruits have naturally cross pollinated, perhaps usually not been fertilized by their own pollen nor perhaps even by that from other flowers in the same cluster or yet the same tree, but from some tree of a different variety. Wind and insects are the chief carriers of the pollen which impresses parental characters upon the ovules in the flowers of our Northern Spy apple or Salway peach so the seedlings may be better, but the overwhelming chances are they will not be even as good. This form of reproduction, continued for countless centuries, has mixed things up so that seeds cannot be relied upon in the classes mentioned. The exceptions are so conspicuous that they prove the rule.

FIG. 119—PRECOCIOUS CLEFT GRAFTS

Lower cion set five apples the first year and the upper two had several fruits the second year.

Among peaches the Honey group, grown to some extent in Florida, and the Heath Cling come fairly true to type from seed. Among apples it is said the Duchess of

Oldenburg, the Yellow Transparent and some other Russian varieties do the same thing. In spite of much discussion two or three decades ago it seems settled now that the influence of pollen does not noticeably affect the character of the fruit which contains the cross-pollinated seed. But this is a topic which does not concern the present discussion.

FIG. 120—TREE PEDDLERS' SHEDS AT NURSERY

Each peddler has a numbered shed where he makes up his packages of trees bought from the nursery.

199. Northern Spy seedlings.—W. T. Macoun of Canada grew 100 Northern Spy seedlings concerning which this summary is presented: 35 per cent resembled the parent in general appearance, 12 per cent in form, 39 per cent in flesh, 19 per cent in color, 35 per cent in flavor and 28 per cent in no marked resemblance. Most of the seedlings, like the parent, were late in coming into bearing. This investigator concludes that the Spy is one of the best parents to use in cross breeding, since it has impressed its good characteristics on a large proportion of its progeny, although a self or nearly self-sterile variety.

200. Importance of graftage.*—Graftage, while one of the most important of horticultural processes, is one of

*Paragraph 200 has been considerably condensed from Technical Bulletin No. 2, by F. A. Waugh, of the Massachusetts Agricultural College.

the most intricate. Because of its importance and the difficulties in solving its problems it has given rise to much study and many theories often based on imperfect observations in disregard of obvious and simple facts.

Graftage is said to be the union of a cion with a stock. So far as nurseryman and fruit grower are concerned this is the prime aim. Success or failure from their standpoint depends upon the nature of this union. The terms good and poor unions, are among the commonest in horticultural parlance; yet their meaning is generally

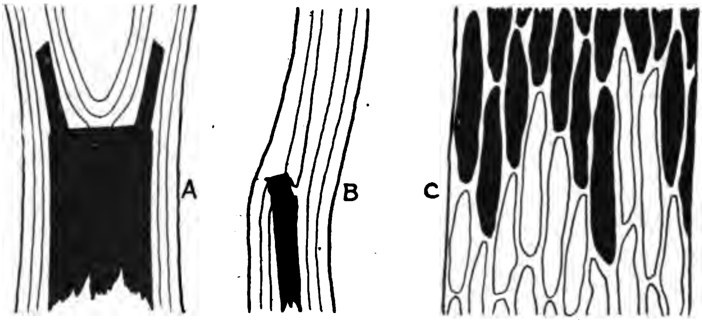

FIG. 121—DIAGRAMS OF GRAFT AND BUD CROSS SECTIONS

A, cleft graft three years old; B, bud graft at three years; C, separateness of cells in stock and cion. (Black parts in A and B represent stock; in C, the cion.)

conjectured. The easy statement that stock and cion grow together does not satisfy the question, *How* do they unite? The popular idea is that the union is like the knitting of a broken bone, also that both stock and cion produce new tissue which commingle more or less as human skin does after the surgical operation of skin grafting. But both these suppositions are vague and far from the truth. Possibly in herbaceous grafting where soft growing tissues are used there may be unions of these characters, but even in such cases the blending seems to be purely local; for original stock and original cion maintain their individuality—each will produce fruit after its kind.

In graftage of mature wood such a blending is impossible; for with the exception of the cambium layer both stock and cion consist almost wholly of dead heart wood and dead bark which cannot unite with anything.

It is different to say the cambium layers of stock and cion unite. But even this statement does not explain

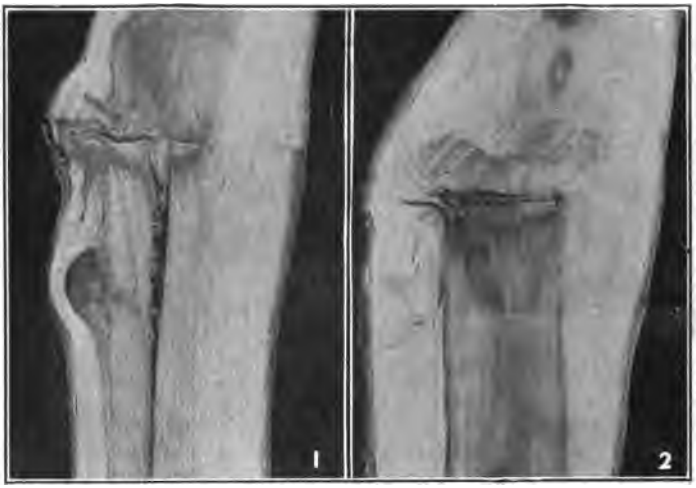

FIG. 122—SECTION OF APPLE GRAFTS
1. Transverse section. 2. Longitudinal.

the process, though it leads in the right direction, for the cambium and a few layers of cells on each side of it are the only part of an exogenous stem really alive. Upon it depends the possibility of a graft union.

Even naked eye examination of cross or transverse sections of successful grafts several years old will show (1) that cion and stock have not united and (2) that wood produced after the union is as continuous as in an ungrafted stem. At least in the layers that bury a graft junction whatever difference there may be is not apparent. The truth of the diagram (Fig. 121) is fully sup-

ported by photographic cross sections of both grafted and budded stems (Fig. 116). In every case the line of demarcation between stock and cion and also the continuous envelopes of new tissue may be clearly seen. Thus it is evident that: 1. Stock and cion do not unite; they remain distinct. 2. Annual layers produced after grafting do not unite in the common meaning of that

FIG. 123—PLUM GRAFTS SHOWING CONTINUOUS LAYERS OF NEW WOOD
The old wood in the specimen on the right has been partly eaten out by ants.

term; each is complete and continuous. 3. In hardwood graftage "union" of stock and cion is different in its physical nature from the sense of common speech.

These simple obvious conclusions suggest questions and doubts which do much to disguise the main facts. For instance, the horticulturist knows that when a pear cion is grafted on a quince stock, every bud above the union will produce pears and every one below, quinces.

But there is a division (and there must be) between

the two kinds of wood; what is its nature? How definite is it? Is it physically strong or weak? Would answers to these questions be more than speculations? It must be remembered, however, that such answers are beyond the conclusions cited above and that the facts so far presented are not affected by the following discussion.

FIG. 124—CHERRY CION ON PLUM STOCK
Notice continuous annual layers of wood.

Sections of grafts (Fig. 124) show that in spite of the longitudinal continuity of the annual layers there is sometimes a plainly visible line of demarcation between the wood of stock and cion at right angles to the longitudinal growth, yet the microscope does not reveal the secret of individual cells which compose the tissue. One can nearly always see less with the microscope than with the naked eye! In the section shown in Fig. 132 and magnified about 1,000 times, the little knot near the middle accidentally shows one point on the line of junction, but the vessels and the cells run from end to end without interruption. So it is harder than ever to see where stock ends and cion begins. Hence those gardeners who have been dreaming of producing new kinds of plants by grafting must needs wake up; for no

FIG. 125—DEFECTIVE PEAR BUD GRAFT ON QUINCE STOCK
Probably due to incompatibility of stock and cion. Notice cleanness of break.

matter how closely the two kinds of cells may be against each other their contents never mingle to produce a new cell. Every cell is the production by division of some other cell; never the product of fusion of two parent cells (Fig. 121). The commingling of stock and cion cells is purely physical, not physiological.

In budding, merely a form of graftage, the layers of new growth are continuous—just as in the graft. A successful bud graft cut (Fig. 116) shows precisely the same conditions as in grafting, except that the line of demarcation is less easy to see.

The physical strength of unions is often discussed by horticulturists, many of whom claim that this is a point of weakness (201). Others claim that a successful graft union is the strongest point of the stem. Common observation shows that the region of graftage is more or less swollen by the deposition of woody tissue, and cross sections at such points show very close-grained wood. Often when grafts are cut open and dried the tissues check and split less at the junction point than above or below, thus showing extra strength of fibers. Observation also shows that when winds break off branches in old orchards a majority of the fractures occur not where the grafts have been made but at other points.

Yet grafts do sometimes break even after years of apparently healthy growth. Why? Possibly because of physiological unlikeness or aversion (if such a term may be permitted). The wound heals slowly or poorly; loose primary or scar instead of stronger tissue fills the space and weakness follows. Clairgeau pear on quince and domestica plum on peach are familiar examples. But setting aside such cases, if stock and cion are congenial to each other and if the cion (or bud) grows at all, the union should be good. Poor manipulation will cause many failures of grafts to grow, but will rarely affect strength of union in grafts which live. All degrees of physical strength may be seen in graft unions from those

FIG. 126—PROPAGATION IN GREENHOUSES

1. Orchids on benches and in hanging pots. 2. Cyclamen large enough for sale. 3. Geraniums by the 10,000 in a large commercial plant.

stronger than the contiguous parts of the same stems to those incapable of holding themselves in place.

201. Physical strength of graft unions. From the standpoint of plant anatomy and physiology grafts may be weak in several ways. 1, Physical weakness at point of union; 2, cion leaves may find it difficult to elaborate sap taken up by stock roots; 3, stock roots may find difficulty in assimilating plant food elaborated by the leaves; 4, there may be an interruption in the upward flow of sap due to faulty connection of the xylem (203) vessels at the point of union; 5, a similar one in the downward flow, due to faulty union of the phloem (202); 6, the quantity of sap taken up by the root may be too much or too little for the proper supply of the cion; 7, the amount of elaborated sap from the cion may be either too much or too little for proper feeding of the stock.

FIG. 127—WEEPING MULBERRY ON ERECT STEM

Concerning these points N. O. Booth of the Oklahoma station has been conducting experiments upon which he has made a progress report from which the following points are taken. Unfortunately, a fire destroyed later material and data, so the preliminary report is obliged to stand by itself.

Physical weakness is a difficult question because of the variation between different trees and different unions of stock and cion. To test it, the wood of 10-year-old

FIG. 128—DIGGING TWO-YEAR NURSERY TREES BY HORSE POWER
Ten-horse or mule teams are very popular with most nurserymen.

trees was tested as to its physical strength by a machine used for such purposes. Except in the last case cited

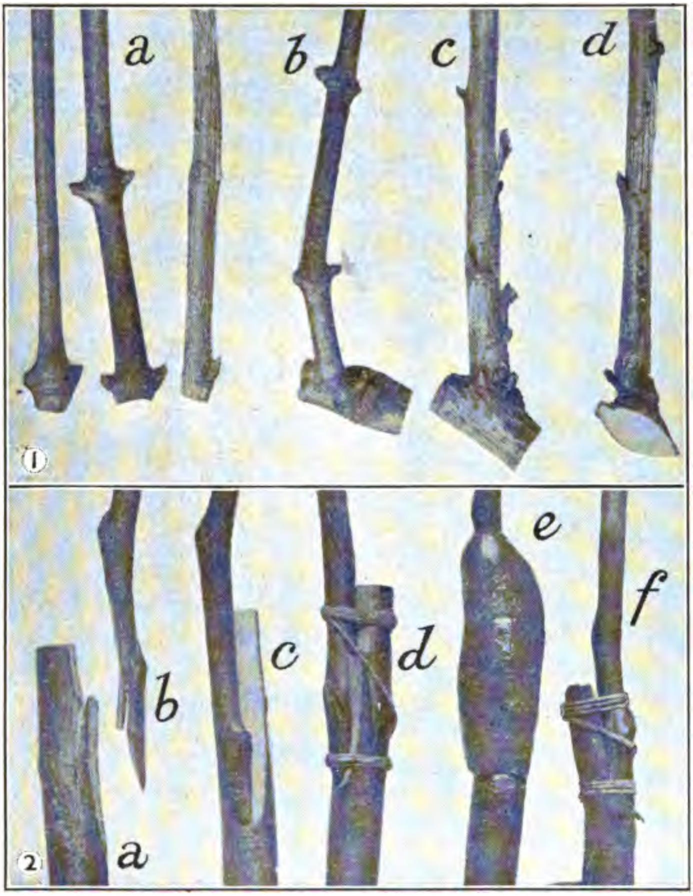

FIG. 129—CUTTINGS AND WHIP GRAFT

1. a, straight cuttings; b, c, mallet cuttings; d, heel cutting. These methods are all used for grape propagation. 2, whip or tongue graft; a, stock; b, cion prepared; c, stock and cion fitted properly; d, parts tied together; e, completed by waxing; f, whip graft on root.

below, the tests were purposely made within three weeks of the tree felling, because it was believed green wood rather than seasoned represents more nearly conditions in growing trees.

TEST OF TRANSVERSE BREAKING STRENGTH

	At union point, lbs.	Above union point, lbs.
Plum, first block	2,540	4,750
Plum, second block	3,160	4,950

To eliminate possible discrepancy due to the breaking point of the union being closer to the ground, and hence possibly in softer wood, the next block was broken above and below as well as at the union.

TEST OF TRANSVERSE BREAKING STRENGTH

	At union point, lbs.	Above union point, lbs.	Below union point, lbs.
Apricot, first block	3,300	8,260	4,100
Apricot, second block	2,560	7,940	——

Tensile strength of one-half-inch strips of apricot: No. 1 broke at union with 1,330 pounds pull; above, 1,550; No. 2 broke slightly below union with 2,870 pounds pull, slightly above 1,770, but would not break at union.

TEST OF TRANSVERSE BREAKING STRENGTH

	At union point, lbs.	Above union point, lbs.
Apricot, seasoned four months	1,930	4,355

The results, Professor Booth points out, "are very positive and it does not seem at all likely that further tests will invalidate the statement that for many trees the point of union is a real and evident weakness. It is true, however, that all three trees tested were apparently strong, had made vigorous growth and had never broken in any way. They were about eight inches thick and about 10 years old. For orchard purposes this weakness does not appear to be of importance. There is also no question but that the thickening of the trunk, which usually shows at the point of union, may lessen materially the weakness of the trunk at this point."

202. Phloem, that portion of a fibro-vascular bundle in plants containing the bast and sieve tissue. In exogens

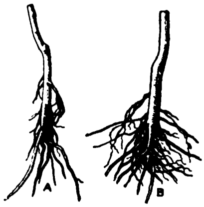

FIG. 130—TWO YEAR SPY BUDDED TREES

A, stem cut at 15 inches and grafted. B, Uncut. This shows that top-working checks growth. It also delays bearing.

it is always sharply defined from the remaining portion (xylem, 203) by a layer of cambium. The inner bark is derived from the phloem, the wood from the xylem. The elaborated plant food from the leaves passes down and is distributed by the phloem.

203. Xylem, or woody portion of a fibro-vascular bundle which contains the larger continuous air-holding vessels and the walls of whose cells are often thickened and lignified. The xylem is separated from the phloem (202) by the cambium, when there is any, and it usually occupies the side of the bundle toward the center of the stem. Water with the mineral compounds in solution passes up through the xylem to the leaves.

204. Limits of graftage. Theoretically botanists and nurserymen have limited graftage to the exogens, plants which have a cambium layer in a definite region beneath a bark layer; for the process depends upon the intimate union of this layer between stock and cion. Of the 151

FIG. 131—BURLAPPED FOR SHIPMENT

Trees so handled have usually been root pruned for two or more years to have large bunches of short fibrous roots. They are almost sure to grow when so treated.

orders, 890 genera and 4,200 species listed in Gray's Field, Forest and Garden Botany, 110 orders, 650 genera and 3,000 species come under this ruling and (theoretically) may be grafted, while the balance, the endogens which lack the cambium sheath (oat, bamboo, palm) cannot be grafted. With experimental exceptions (Chapter XII) this is so.

Among exogens botanical relationship seems in most cases to be fundamental to success in graftage which is usually easy between varieties of the same species (apple

FIG. 132—GREATLY MAGNIFIED SECTION THROUGH YOUNG GRAFT.
Round mass of scar tissue near center merely accidental.

upon apple) and often between closely related species (pear upon quince, or plum upon peach). Sometimes species more remotely related than the genus will prove successful; for instance, apple or pear (*Pyrus*) upon thorn (*Cratægus*). But rarely, and then mostly experimentally, can distantly related species be grafted successfully; probably not at all from a business standpoint.

A few instances may emphasize these points. While pear is commercially grafted upon quince to form dwarf trees, apple is seldom or never so treated, and quince

does not succeed on either pear or apple; gooseberry may be grafted upon only one species of currant (*Ribes aureum*) but currants do not succeed on gooseberries; apples succeed commercially only upon apple stock; peaches and plums will each grow upon the other. For years Prunet tried to make chestnuts grow upon oak in the hope of preventing certain diseases. His conclusions are that the plan will not succeed commercially, though he was successful in many instances. Daniel and others have made many remarkable grafts between distantly related species, so the theory that species must be more or less closely related has been knocked on the head. But from a commercial standpoint, the theory is still operative and probably will continue to be.

While species of the same genus *may* be grafted successfully, it may not be profitable so to do. From a physiological standpoint the best index of success is the general thriftiness of the plant so produced; from a business standpoint, the fact that nurserymen and other plant propagators stick by the methods that make them most money. To be successful, stock and cion must both unite firmly without seriously checking plant activity and continue growth until normal fruit is ripened.

205. Common rules of graftage. Graftage in one form or another and with various species of plants may be done during almost any month provided the method be adapted to the time of year and to other conditions. Always it is essential that the parts fit snugly. Preferably the cambium layer of the cion should be in intimate contact with that of the stock. This layer is most active during early spring when the buds are swelling and the leaves are expanding. A second period of activity occurs usually soon after midsummer, but sometimes not until early fall, dependent largely upon the amount of moisture in the soil. During these two periods wounds heal most rapidly and union between stock and cion is most certain. At other times, since the cambium becomes firmer

and less distinct because of the development of other tissues from it, the union of stock and cion is less sure. At such seasons it is also more important to cover the wounds to prevent or check loss of moisture from the wounds.

Wax (285) is usually used in outdoor work where the wood itself is cut, but where only the bark is cut, as in budding, it is necessary to bind only the bark firmly over the bud and the wound until the union is complete. Then the bindings must be cut to prevent strangulation.

FIG. 133—STEAM TREE DIGGER IN BIG NURSERY

Steam tree diggers are used only in the largest nurseries. They are very satisfactory

It is an erroneous theory that cleft grafts will die if the adjacent bark of the stock is wounded seriously. The bark serves scarcely a greater purpose than that of protecting the tissues beneath. Cions often grow in the almost total absence of the bark of the stock, provided proper protection is given and the formation of new bark thus encouraged.

It is necessary that each cion have at least one sturdy bud. As a rule, only mature buds, or those approximately mature, are employed, though in herbaceous grafting younger ones may be used. Cions may be inserted in whole or piece roots, crowns, trunks, branches; in fact,

any part that will meet the requirements of cion nutrition, as tubers of dahlia, potato, sweet potato. The way of setting may vary from merely placing a bud beneath the bark to inserting a woody cion in the wood of a stock, as in cleft grafting. Again the work may be done with dormant specimens at any time of year or upon active wood during the growing season. The methods and variations are countless; but in general only a few are simple and quick enough to be of wide or general use. The others are more for the specialist and for finicky subjects which the average nurseryman, gardener or florist will not "fuss with."

FIG. 134—UNIFORM BLOCK OF ONE-YEAR BUDDED BARTLETT PEARS

Notice the even stand. The great majority of the trees are four to five feet tall with occasional specimens 5½ feet.

CHAPTER XI

IS GRAFTAGE DEVITALIZING?

206. Points involved in discussion.—Nowadays we hear little discussion as to whether or not graftage is a devitalizing process. Perhaps this is largely because of investigations made at various domestic and foreign experiment stations and teachings of agricultural colleges and schools at home and abroad. But even so late as the early nineties, discussion was rife and even such well-known writers as Burbidge of Ireland and Bailey of the United States took opposite sides. Beginning about a decade later Lucien Daniel and other European investigators began to present results of their exhaustive studies which as yet seem to have made little impression in America. As Daniel is copiously quoted in this volume, it is thought advisable to present the picture of conditions as they existed in the early nineties before he began to publish his findings. Therefore the next few paragraphs have been condensed from an address by Bailey before the Peninsula Horticultural Society at Dover, Delaware, in 1892.

To the popular mind graftage seems mysterious. People look upon it as akin to magic, opposed to nature. Strange, for the operation is simple! The process of union is nothing more than the healing of a wound. It is not more mysterious than rooting of cuttings. Natural grafts are fairly common among forest trees. Occasionally union is so complete the foster stock entirely supports and nourishes the other. Stem cuttings, however, are rare among wild plants; in fact, there is in the North but one common instance: certain brittle willows whose twigs drop in moist places and sometimes take root.

Why is union of cion and stock any more mysterious or unusual than rooting of cuttings? Is it not simpler and more normal? A wounded surface heals over to protect the plant. When two wounded surfaces of consanguineous plants are closely applied, nothing is more natural than that the nascent cells should interlock and unite. But why bits of stem should throw out roots from

their lower portion and leaves from their upper portion when both ends may be to every human sense exactly alike, is a mystery.

It does not follow from these propositions that graftage is a desirable method of multiplying plants, but simply that direct and positive evidence is needed. Much has been said concerning the merits of graftage. Opponents have made sweeping statements of the perniciousness of the system. Discussion started in an English journal from an editorial which opened as follows.

FIG. 135—STAGES OF CLEFT GRAFTING

1. Sawing limb to form stock. 2. Making the cleft. 3. Placing the cions. 4. Waxing. 5. Cion growing. In this case both cions grew, but one was accidentally broken off.

"We doubt if there is a greater nuisance in the whole practice of gardening than the art of grafting. It is very clever, it is very interesting, but it will be no great loss if it is abolished altogether. It is for the convenience of the nurserymen that it is done in nine cases out of ten, and in nearly all instances it is not only needless, but harmful. . . . If we made the nurserymen give us things on their own roots, they would find some quick means of doing so."

For two years discussion continued, and many excellent observers took part. Some of the denunciations of graftage are [condensed and the statements of various writers run together] as follows:

"Grafting is always a makeshift, and very often a fraud. It is in effect a kind of adulteration. Grafted plants are open to all kinds of accidents and disaster, and often soil, climate or cultivator are blamed for evils which originated in the nursery. If, in certain cases, grafting as a convenience must be resorted to, let it be root grafting, so that eventually the cion will root itself in a natural way. Toy games, such as grafting and budding, must be abandoned and real work begun on some sensible plan. Any tree that will not succeed on its own roots had better go to the rubbish pile at once. We want no coddled or grafted stuff when own-rooted things are in all ways better, healthier and longer lived."

These quotations show the positiveness with which graftage has been assailed. As presumption is in favor of any universal practice they possess extraordinary interest.

The assumptions underlying these denunciations are three: 1. Citation of instances in which graftage has given pernicious results. 2. Affirmation that the process is unnatural. 3. The statement that own-rooted plants are better than graft-rooted plants.

1. Citations of injurious effects of graftage are usually confined to ornamental plants, commonly the tendency of stocks to sucker and choke grafts. Conversely, in numerous instances it does not occur; for instance, in peach, apple, pear, and many other fruit trees, and in very many ornamentals. In fact, it is probably no more common than is suckering of plants grown from cuttings; for instance, cutting-grown or sucker-grown plums. These remarks apply with equal force to all citations of the ill effects of graftage; the cases simply show that the operation is open to objections in the particular instances cited; no proof that with other plants graftage may not be a success. Graftage has been indiscriminately employed, and there have been many failures, but this does not prove the process wrong. If there are plants upon which graftage is successful the operation itself is not wrong, however many cases there may be to which it is not adapted.

2. That graftage is unnatural, and therefore pernicious, is a fallacy. There is nothing to show it is anything more unnatural than making cuttings. If naturalness is proved by frequency of occurrence in nature, then graftage is the more natural. But the whole discussion of mere naturalness of any operation is aside from the question; for every garden operation—transplanting, pruning or tillage—is in some sense unnatural; yet these "unnatural processes" sometimes increase plant longevity and virility.

3. An assumption held with dogmatic positiveness by many writers is that own-rooted plants are better than foster-rooted ones. If mere rarity or lack of occurrence in nature is no proof of perniciousness, the statement admits of argument just as much as any other topic. The citation of ill effects of graftage is no proof that own-rooted plants are better if there should still remain cases in which no injurious effects follow. If it is true that "own-rooted things are in all ways infinitely better, healthier, and

longer lived" than foster-rooted plants, and if "grafted plants of all kinds are open to all sorts of accidents and disaster," then the proposition should admit of abundant proof. The subject may be analyzed by discussing the following questions: a. Is the union always imperfect? b. Are grafted plants less virile, shorter lived than own-rooted ones?

a. It is well known that the physical union between cion and stock is often imperfect and remains a point of weakness throughout the life of a plant (201). But this is not always true. Scores of plants make perfect physical union with other plants of their own species, or even with other species. Therefore, these alone are the plants that should be grafted. The best proof that can be adduced that the union may be physically perfect, is in the micro-photograph published by Prof. C. S. Crandall. [Similar ones are shown on pages 138, 140.] The cells are knit together so completely it is impossible to determine the exact line of union.

Professor Crandall also figures a microscopic section of an apple graft in which the union is very poor, but this graft is made in a different manner, another proof that operation should be suited to subject. These were grafts made upon nursery stock. It would appear that if the union were good at the expiration of the first year it would remain good throughout the plant's life. In order to test this point two apple trees 15 years old and over six inches in diameter grafted at the surface of the ground in the nursery, were split into many pieces in the presence of two critical observers, but no mark whatever could be found of the old union. [Similar conditions may be seen on page 148.]

b. Are grafted plants shorter lived than others? It is evident that a poor union or an uncongenial stock will make the resulting graft weak, a further proof that indiscriminate graftage is to be discouraged. But these facts do not affirm the question.

Many persons hold that any asexual propagation is in the end devitalizing, since the legitimate method of propagation is by means of seeds. This notion appears to be confirmed by Darwin's conclusions that the ultimate function of sex is really to vitalize and strengthen the offspring following the union of characters or powers of two parents; for if the expensive sexual propagation invigorates the type, asexual propagation would seem to weaken it. It does not follow, however, that because sexual reproduction is good, asexual increase is bad, but rather that one is as a rule better than the other, without saying that the other is injurious. Some plants have been asexually propagated for centuries with apparently no decrease of vitality. This fact, however, does not prove that the plant may not have positively increased in virility if sexual propagation had been employed. The presumption is always in favor of sexual reproduction, a point which everyone will admit.

Here is where graftage has an enormous theoretical advantage over cuttage or any other asexual multiplication: the grafted plant springs from sexual reproduction. If the union is physically perfect, as is frequently the case, there is reason to suppose that

grafting between consanguineous plants is better than propagating by cuttings or layers. In other words, graftage is really sexual multiplication; so if seeds have an advantage over buds in forming the plant foundation, graftage is a more perfect method than any other artificial practice—in fact the nearest approach to direct sexual reproduction. So when seeds cannot be relied upon wholly, as they cannot, for the reproduction of many garden varieties, graftage is the ideal practice; always provided, of course, that it is properly done between congenial subjects. It is not to be expected that the practice is adapted to all plants, any more than is the making of cuttings of leaves or of stems, but this fact cannot be held to invalidate the system.

Is there direct evidence to show that "grafting is always a makeshift," a "toy game," that "grafted plants are open to all sorts of accidents and disaster," that "own-rooted things are better, healthier, and longer lived"? These statements allow of no exception; they are universal and iron-bound. If the questions were to be fully met, we should need to discuss the whole art of graftage in all its detail, but if there is one well-authenticated case in which a grafted plant is as strong, as hardy, as vigorous, as productive and as long lived as seedlings or as cutting plants, we shall have established the fact that the operation is not necessarily bad, and have created the presumption that other cases exist. An instance will serve.

In the forties about 100 apple trees were grown from seeds on a Michigan farm, but as most of the fruit was poor or indifferent the trees were top-grafted in the most desultory manner, some being grafted piecemeal with some of the original branches allowed to remain permanently, while others were entirely changed over at once; a few of them grafted on the trunk when as large as broomsticks, the whole top having been cut off when the operation was performed. A few trees which chanced to bear tolerable fruit were not grafted.

Many of the trees died from indeterminable causes; fully half of the deaths have been seedling trees for many years as vigorous as the grafted ones. Of the trees that remain the grafted specimens are in every way as vigorous, hardy and productive as the others. Some of these trees have two tops, one grafted shoulder high in the early days, the other in the resulting top many years later. Those trees which contain both original branches and grafted ones in the same top show similar results—the foreign branches are in every way as vigorous, virile and productive as the others, and are proving to be as long-lived.

This positive experiment compassed by the lifetime of one man shows that own-rooted trees are not always "infinitely better, healthier, and longer-lived" than grafted plants. The illustration may be considered typical of thousands of orchards, containing various fruits in all parts of the country.

The fact may be cited that the old seedling orchards about the country are much more uneven and contain more dead trees or vacant places than commercial grafted orchards of even the same

age. This is due to the struggle for existence in the old orchards by which the weak trees have disappeared, while the grafted orchards, being made up of selected varieties of known virility and hardiness, have remained more nearly intact. If the seedling orchards have suffered more than the grafted ones it must be because they have had more weak spots.

The universal favor in which graftage is held in America is itself a strong presumption in its favor. Growers differ among themselves as to the best methods of performing the operation, but an intelligent American will not condemn the system as necessarily bad or wrong.

Of the vast number of grafted and budded trees sold annually by nurserymen probably half die from various causes before they reach bearing age, but graftage itself plays a small part in the failure, as may be seen in the case of grapes and small fruits, which outnumber the tree fruits in nursery stock, and of which less than one-half reach maturity, and yet these are cutting-grown plants. It is in nineteen cases out of twenty the carelessness of the grower which brings failure.

It is impossible, if one considers the facts broadly and candidly, to arrive at any other conclusion than this: Graftage is not suited to all plants, but in those to which it is adapted—and they are many—it is not a devitalizing process.

CHAPTER XII

DANIEL'S EXPERIMENTS AND CONCLUSIONS

207. Functional capacity of plants.—Daniel gives the following broad generalizations on the relationship between absorption, assimilation and transpiration in plants. By functional capacity is meant the processes involved in the absorption and utilization of crude materials by the plant. If the function of absorption or the total absorption from external surroundings be represented by CA, and the functional capacity of consumption or total consumption at the points where the sap is used up be represented by CV, then in a plant in complete equilibrium as regards its general nutrition CV= CA and $\frac{CV}{CA} = 1$. If, however, aerial consumption is greater than the usual subterranean absorption, then the formula $\frac{CV}{CA} > 1$. This corresponds to growth in dry or poor soil. When absorption is greater than consumption, as in moist or rich soils, the formula becomes $\frac{CV}{CA} <$

Conditions similar to these are sometimes brought about by grafting. The cicatrization of the grafted plants and the intercalcated tissue between stock and cion interfere with the condition of sap, modifying it both in quantity and quality. These modifications of the cion are equivalent to growth in a drier, poorer medium than the normal. In grafting it is also necessary to keep in mind the relative functional capacities of the two grafted plants. For example, if the functional capacity of consumption is greater in the cion than in the stock this condition becomes exaggerated by the scar of cicatrization when the two plants are grafted, and the graft either fails to take or makes a poor growth, corresponding to that in poor dry soil. The chance for mak-

ing a successful graft in such a case is increased if the development of adventitious roots from the cion is encouraged, so that assimilation may correspond more closely to a normal absorption of the cion.

208. Graftage laws.—Daniel draws the following conclusions from certain of his experiments: 1, The relative affinity or difference of functional capacities between stock and cion at different periods of the symbiosis plays a very important role in the success, duration, and biology of all grafts. 2, Environment, weather, etc., particularly sudden changes of environment, have considerable reaction on the whole, a reaction greater than in normal plants. 3, Various irregularities like diseases result from faulty nutrition, due to badly chosen grafts.

FIG. 136—YOUNG APPLE ROOT GRAFT
This is student work.

209. Disease due to grafting. — A study of grafts between various species of Solanum (pepper, tomato, eggplant, etc.) has led Daniel to conclude that many of the physiological troubles of plants commonly considered as diseases are in reality due to the employment of antagonistic stocks and cions.

210. Grafts are of two classes,* anatomical (grafts by approach) and physiological (true); the latter divided into two groups, ordinary and mixed. In the ordinary the stock is deprived entirely of its assimilating apparatus (the green parts) and the cion of its absorbing parts (the roots). In the mixed graft proper the stock may preserve part or all of its assimilating apparatus and the cion part or all of its absorbing apparatus. In grafting by approach success is attained when the two plants grow together in an enduring manner so that if separated a wound is formed. The graft proper is said to succeed when, after having lived a certain time on the stock, the cion produces fertile seeds.

*L. Daniel, *Rev. Gen. Bot.* 12, summarized in Ex. Sta. Record, Vol. 12, pp. 947,-952.

The conditions of success of grafts are of two kinds, extrinsic (conditions independent of the nature of the plant—as soil, temperature, etc.) and intrinsic (conditions dependent upon the peculiar nature of the plants grafted, as method of cicatrization, analogy and botanical relations. The extrinsic conditions necessary to observe by approach are: 1, A temperature sufficient to produce primary tissue; 2, prevention of all conditions which cause rotting or drying of the cicatrized meristem (primary tissue); and 3, maintenance of adherence of the wounds by the aid of ligatures susceptible of being loosened progressively with the growth of the plant.

211. Cicatrization.—Plants cicatrize their wounds either by simple drying of the cut tissues and neighboring cells or by regeneration of tissues by the aid of the primary tissue. All methods have failed with the monocotyledons and cryptogams experimented upon. Hence Daniel concludes that grafting by approach is impossible with plants that cicatrize their wounds by desiccation of the wounded cells and neighboring tissues; i. e., are incapable of regenerating tissue.

FIG. 137—GRAFT WRAPPING MACHINE
A great time saver

In order to learn whether only plants with cambium may be grafted, as generally believed, Daniel worked with many monocots and cryptogams and secured a perfect cicatrization by the tongue graft with gladiolus, day lily (*Funkia cordata*), Caladium, white lily (*Globba coccinea*) and several others, even with one of the club mosses (*Selaginella arborea*). The success of these grafts shows that grafting by approach is possible with certain monocots and that the presence of the cambium layer is not always necessary to the success of all grafts by approach.

212. Analogy.—The difference in hardness and the histological nature of woods may not be an obstacle to anatomical union. A natural, distinct cicatrization occurred between grafted oak and beech, and between fir and linden, oak and ash united by their stems and oak and walnut by their roots. Rose and grape have also been united. Nevertheless, the graft by approach does not always succeed between plants so different. Daniel tried in vain to graft horse chestnut on common chestnut.

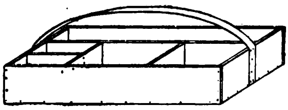

FIG. 138—GRAFTERS' OR BUDDERS' KIT
Tools, cions etc., are carried thus.

FIG. 139—DIGGING LARGE TREES FOR SHIPMENT

1. Forks are used to reduce injury to the roots. 2. Roots are wrapped in moss and straw.

Accumulation of reserve material in vegetative plant parts has no special importance in grafting, as proved by grafting turnip and cabbage, kale and kohl rabi, Brussels sprouts and kohl rabi, and kohl rabi and cauliflower. [These plants, though very different in form as cultivated, are all, except turnip, varieties of one species, *Brassica oleracea*—M. G. K.]. Even grafting by approach between roots of lettuce and aged salisfy succeeded, though the inulin of the salsify did not circulate in the lettuce cells. If the cell contents of one of the plants approached are toxic for the other, the graft fails.

If a large and a small variety are grafted on each other the larger will develop to the detriment of the smaller, which will remain nearly dwarf. Plants of different forms, like kale and cauliflower [see bracket note above], may make good unions. Plants in active growth may be grafted by approach on plants at rest; e. g., seedling cabbage several weeks old was grafted in spring with perfect success on a turnip whose root was fully formed. Grafting by approach succeeds between annuals, biennials, and perennials; also between biennials and perennials. The fact that fir and linden, and *Aralia Spinosa* and *A. Sieboldii* were grafted by approach shows deciduous and evergreen plants may be intergrafted.

213. Extrinsic conditions.—With grafts proper all extrinsic conditions are present, but in cutting off the top of the stock and suppressing the absorbing apparatus of the cion, there is danger of the death of both plants. Another fundamental extrinsic condition of success must be maintenance of life in the two plants till success is complete.. The cion is sometimes preserved by being placed in water as soon as made to prevent its drying out, keep the surface clean, and prevent the formation of sugar or other material on the cut surfaces. This might interfere with the free passage of sap from stock to cion.

In order that the cion may grow its turgescence must be reestablished. This is secured by the imbibition of the crude sap of the stock by the cells of the cion, and occurs more quickly according as the crude sap is presented in considerable quantity, but also more quickly if the initial turgescence of the tissues of the cion has not been diminished during the preparation of the graft and its being put in place. This explains why it is necessary to operate quickly and why cuttings are often made under water where the cion preserves much of its turgescence and produces good results. It also accounts for the good effects of wax-like material used in open air grafting; the utility of the collar graft, because the osmotic force is strongest at this level; and the importance of the time of day in operating, because the osmotic force varies, being strongest in the evening (hence the greater success then). The re-establishment of turgescence in the graft is considered fundamental to success, therefore it is impossible to graft parts incapable of retaining turgescence or which do not possess it.

214. Intrinsic conditions.—In the graft proper plants incapable of regenerating their tissues cannot be grafted. In gladiolus and

Funkia cases cited above, the anatomical cicatrization was effected by the parenchymatic tissues. No liber or fibro-vascular structure was observed to form between cion and stock. Thus the transport of sap was hindered, and sooner or later both parts died. By utilizing the aerial roots of some monocots to supplement the absorption of the cion, success was attained with several plants. This shows that failure of grafts with monocots capable of regenerating their tissues is due to insufficient vascular communication, since it becomes possible when a complimentary apparatus is supplied.

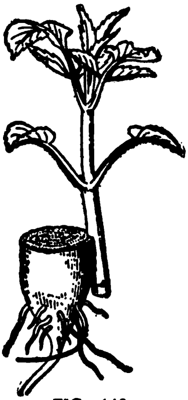

FIG. 140—CUTTING ON DAHLIA TUBER

Plants with active cambium layers, which may be inarched, cannot always be grafted by the graft proper, since the common European bean (*Fabia*) and the kidney bean, which graft easily by approach, have always failed when grafted by the graft proper, no matter what precautions were taken.

Differences in wood and bark are not obstacles to success in the graft proper. Thus there is a great difference in the thickness and strength of safflower and annual sunflower; between sunflower and Jerusalem artichoke; young cabbage and root of turnip; root of cultivated carrot and that of fennel; nevertheless, these [pairs of] plants united perfectly. These same facts were observed with trees; the graft succeeded between chestnut and oak, pear and hawthorn, quince and hawthorn, in spite of marked differences in the barks. From these and other grafts it is concluded that hardness, density, and elasticity of wood are secondary in the success and duration of grafts, but it is not the same with conduction.

When the differences of sap conductions are too great, grafts will not succeed; e. g., lilac and ash, cherry and almond, Cotoneaster and chestnut, which grow the first year, then die without fructifying. The duration of the graft is then very variable and depends for its value on differences in conduction between cion and stock. Thus pear grafted on quince endures for a shorter period than pear on pear seedling [the Yeoman's dwarf pear orchard at Walworth, New York, bore profitable crops for over 50 years! M. G. K.] When the differences of conduction are too great between plants, the mixed graft is sometimes used successfully where the ordinary graft fails. By using it Daniel united *Vernonia praealta* and *Xanthium macrocarpum,* which failed by ordinary grafting.

Daniel has succeeded in grafting plants whose cell contents presented very marked differences; e. g., Chicoreaceæ and Euphorbiaceæ, which have different latex contents. Previously it had been held that plants with milky juice could not be grafted.

Grafts were made to determine what influence reserve material in plants may have on grafting. The easy grafts on roots of car-

rot and parsnip show that the presence of reserve material is no obstacle to success. Those of tomato on potato, annual sunflower on Jerusalem artichoke, etc., show that the formation of tubers on the stock takes place even when the cion is incapable of producing tubers itself. In grafting in September a young cabbage on a purple-topped turnip, which would have begun to thicken its root, in October, the thickening came in the April following, when the cion became plethoric. It is, then, the cion which by its mode of nutrition commands the function of reserve material in the stock.

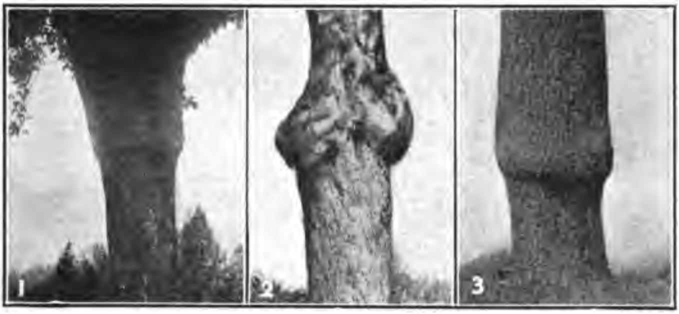

FIG. 141—SWELLINGS DUE TO GRAFTAGE

1. Large growing apple on small growing stock. 2. Swelling of tissues at point of union. 3. Pear on small growing stock.

The inverse graft of plants susceptible of forming tubers on a plant which does not yield tubers may be realized. Daniel succeeded in grafting *Helianthus loetiflorus,* a species with an enlarged rhizome, on *H. Annuus,* an annual species which does not form tubers. The cion grown entirely above the soil was unable to form tubers. The reserves passed into another form in the stock, which took a development altogether abnormal and became very ligneous. Potato grafted on eggplant and on tomato has been observed to form aerial tubers and thus store up its reserve material.

215. Analogy in habitat seems to be a more or less important factor. Thus *Phlox decussata,* which grows in humid soils, has not been successfully grafted by Daniel on *P. subulata,* which grows on dry soils; though parsley, which prefers a dry soil, succeeds when grafted with *Sison ammonium,* which prefers humid soil. In the case of trees, pears are grafted on quinces in rich soil and on pear seedlings in poor soil, etc. Different soils, then, are not the most serious obstacles to success in grafting, but they seem to have more or less marked influence on the duration of the graft.

If a dormant ligneous cion is grafted on an active ligneous stock, success follows, but does not follow if conditions are reversed. With herbaceous plants, an active cion may be grafted on

a dormant stock and succeed. When cion and stock do not come into activity about the same time, the graft may succeed, but its duration will be shortened.

In order to study the limits of the possibility of grafting, experiments were made with Rosaceæ, Umbelliferæ. Leguminosæ, Cruciferæ, Solanaceæ and Compositæ. With Rosaceæ, Leguminosæ and Cruciferæ the limit of grafting seems to be confined to genera of the same tribe. With Solanaceæ and Umbelliferæ grafts were successfully made between different tribes. With Compositæ the limit seems to be the sub-family.

216. Herbaceous grafting has been successfully practiced experimentally by Daniel,* with pea on bean, cabbage on kohl rabi, turnip, stock and other related plants, fennel on wild carrot, carrot on parsnip and vice versa, celery on parsnip, winter lettuce on wild prickly lettuce, spring lettuce on salsify, salsify on scorzonera, toadflax on snapdragon, almond, peach and prune on cherry.

This experimenter also found: that grapes will unite between genera of

FIG. 142—BORDEAUX MIXING FOR SMALL NURSERY

One of the upper barrels contains blue stone stock solution, the other lime solution. The tubs are used to dilute these solutions. The lower barrel mixes these two solutions which then pass as one to the spray tank through a sieve. A larger hose would be a decided improvement.

*Extended summary in Experiment Station Record, Vol. 5, p. 1089.

the same order; 2, hollow-stemmed annuals unite, while the pith is functional; 3, with trees the union is easily made and the swelling at the point of union is reduced to a minimum; 4, root grafting of herbaceous plants is most successful; 5, duration of grafted plants is more or less modified by the graft, a, annuals on biennials or perennials continue to be annuals, i. e., at the end of the growing season they die and cause the partial or total death of the stock; b, biennial grafts with rare exceptions remain biennial on both biennial and perennial stocks and induce the death of the stocks; c, perennial grafts on annual or biennial stocks die with the stocks, but may be used as grafts on perennial stocks prior to this event. 6, herbaceous grafts are less resistant to cold than are mature wood grafts; 7, time of flowering is slightly retarded among annual grafts, and at least for the first year among biennials and perennials; 8, stock and cion are influenced reciprocally—sometimes cion controls stock, sometimes vice versa, and sometimes both classes of cases may be found in the one kind of graft but with different specimens. 9, Cultivated varieties grafted on wild ones generally show deteriorated quality in the fruit; 10, seed produced in such cases (9, just mentioned), some seedlings revert to the wild type and largely lose value as food plants, hence it is concluded that inferior stocks should not be selected for grafting when seed is to be saved for planting; 11, reserve food of a stock is rarely utilized by the graft of a plant of another family.

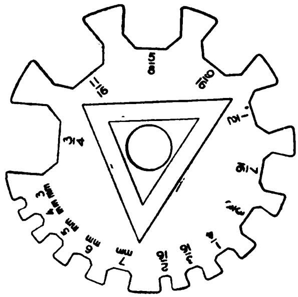

FIG. 143—HANDY STYLE OF TREE CALIPER

Circulation of liquids in grafted plants presents two extremes to consider: 1, cases where water absorbed by the stock passes in small quantity into the coin; and 2, where it is abundant. In the former (the commoner) the cion makes less vigorous development but flowers and fruits more abundantly than in Case 2 where the vessels are larger, the sprouts more vigorous and the flowers and fruits less abundant, as in the case of a tree too well nourished. At first these phenomena are physical, but later chemical changes modify the cell contents as shown by starch or sugar formation under the influence of the graft in certain cases.

217. Reciprocal influence of stock and cion.—Daniel has demonstrated both direct and indirect influences of stock on cion in grafted plants. From his experiments he deduces that variations in the graft may be due to changes in nutrition or may be specific; that is, they may appear in particular characters of stock and cion more or less independently of environment. The effects of grafting on the general nutrition may be shown in four ways.

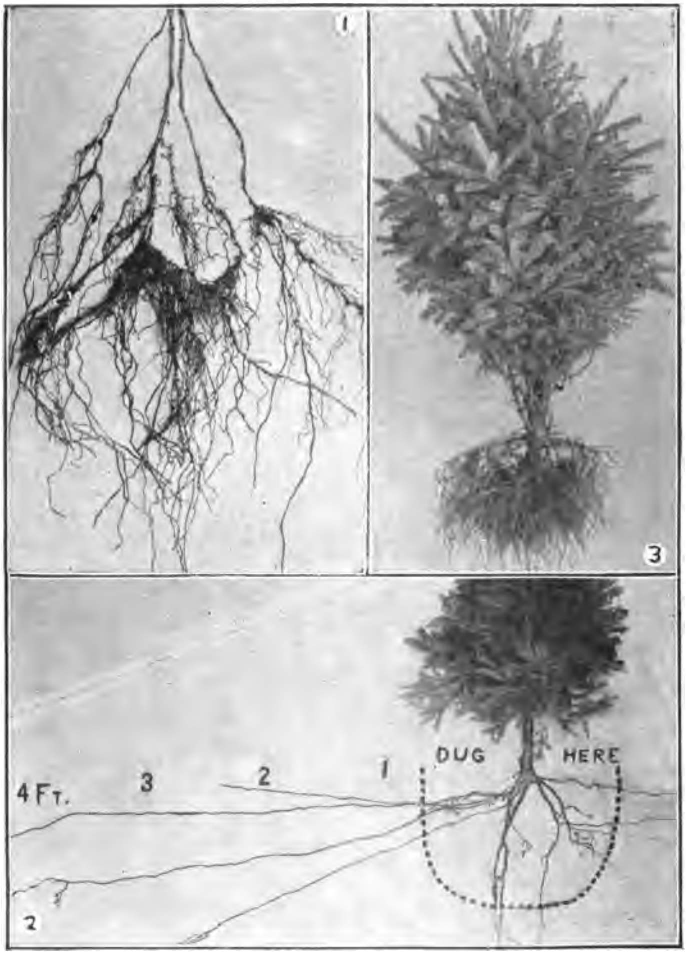

FIG. 144—WHY ROOT PRUNING IS DESIRABLE

1. Roots of evergreen as ordinarily grown in nursery. 2. Dotted line shows where plant would be dug with loss of roots. 3. Evergreen root pruned as shown at 2 but after new roots have developed. Such plants are well worth their extra cost.

1. The size of the vegetative organs of stock and cion may be modified. If a herbaceous plant is grafted on itself, the general nutrition is interrupted in inverse proportion to the activity of the cambium layer at the time the operation is performed. The same principle applies in the case of grafts between different plants of the same variety.

In the case of grafts between plants of different varieties, species or genera, the reciprocal reactions are much more complicated by the imperfect functional adaptations. In herbaceous grafts the callus has the same effect on the cion as would placing it in arid soil—it is dwarfed. In determining what species of the same order may be successfully grafted, similarity of habitat is of more importance than relationship. In the case of ligneous plants, geotropism (219) is a cause of variation, although this has generally been denied heretofore. It is also shown that a branch that has lost its negative geotropism does not always regain it if grafted on the main axis of the stock, at least in the case of the pear.

2. The flavor of the edible parts, size, chemical composition or season of development, may be modified. If the union is perfect, grafting in general produces a change of flavor in the edible parts of vegetative organs, either in the nature of improvement or deterioration in quality. There is almost always a reduction in size of the part which sometimes fails entirely to develop in edible form. For the operation to have practical interest, the diminution in size must be compensated by increase in quality. When the edible parts belong to the reproductive organs, grafting herbaceous plants may or may not cause the enlargement of the pericarp of fleshy fruits or of the seeds in dry fruits. There is no known principle of general application. The flavor of the fruit depends mainly on the completeness of the union and the quantity of sap the cion receives. This principle applies to ligneous and herbaceous plants alike.

3. The development of the reproductive organs of the cion may be accelerated or retarded. The flowering season of the cion may be affected very differently, according as the plant is annual, biennial or perennial, according to the age and nature of the cion, and according to the kind of graft employed. Grafting may induce variation in the arrangement of flowers, in the season of opening or falling of the petals, or in their color.

4. The relative resistance of stock and cion to parasites and other injurious organisms or substances may be modified. The principal parasites that attack grafts before the union is complete are molluscs, worms, sowbugs, insects and molds. These parasites may affect stock and cion differently. The parasites that attack grafted plants after the union is complete, are in the order of the extent of their ravages, insects, myriapods, fungi, and other vegetative parasites, and molluscs. The more imperfect the union of stock and cion, the more serious are the attacks; so much so that their extent and severity may be said to be a criterion of the degree of perfection of the symbiosis.

FIG. 145—TREE DIGGER AT WORK IN PEAR NURSERY ROW

The digger passes under the nursery row and the trees are lifted and carried to the packing or storage quarters

218. Reasons for the above effects.—The theory by which Daniel seeks to explain these facts is in brief as follows: The nutrition of stock and cion is modified by two causes which may act in the same or contrary directions. These are (1) the callus consequent on the operation, and (2) the difference between the peculiar functional capacities of stock and cion, such as differences in structure, special diastases, differences in composition of the crude or the elaborated saps, etc. The phenomena produced are dependent, not only on the nature of the plant, but intimately so on environment.

From this theory certain conditions of success in grafting may be deduced. The protoplasm of stock and cion must not, as a result of the operation, be modified beyond that definite point at which poisoning sets in or at which the essential properties of the living substance, as nutrition and motility, are destroyed. Destruction of the protoplasm may result from either of two causes: (1) action of plastic or waste products brought together suddenly, causing immediate poisoning or gradually causing slow poisoning. These products may give rise through mutual reactions to other injurious products. (2) Deficiency or excess of water in stock or cion consequent upon grafting.

Daniel demonstrates the insufficiency of the hypothesis of relationship and that of similarity in composition of elaborated saps to account for the success of a graft or to explain its variations. He reports a large number of experiments, each illustrating a different variation, produced directly by a mutual reaction of stock and cion. Specific variations differ much in degrees according to the nature of the plant and even according to the part of the cion. The principle applies alike to herbaceous and woody plants. Specific variations result in a more or less complete blending of the characters of stock and cion; or more strictly, these characters appear side by side but separate and distinct.

219. Geotropism, the tendency of plant parts to grow downward toward the center of the earth, as in ordinary roots. Negative geotropism (apogeotropism) is the growing away from the earth, as in ordinary stems.

220. Transmission of grafted characters by seed.—From certain experiments Daniel concludes that variations due to nutrition are in some cases transmitted by seed collected from the cion, even when no morphological changes are apparent in the cion itself. Such cases show that the immediate influence of stock on cion may be less than the indirect influence of the offspring of the cion. Seed grafts of wild carrot on the cultivated half-long red variety showed clearly such a mixture of the characters of stock and cion that the resulting plants might be considered true crosses or graft hybrids produced by the influence of stock on embryo. These and similar experiments show also that by grafting a wild and a cultivated plant the former may be made to acquire definite qualities which can be improved by selection. Experiments showed

also that these variations, which the experimenter classes as specific, are at least in certain cases transmitted by the seed.

Daniel also concludes that grafts may influence the somatoplasm (223), though not always. In many plants the effect is often very slight, especially in woody plants in which the ligneous framework gives to the plant a much more fixed form than herbaceous plants possess. When this influence exists, it most often affects characters of little taxonomic importance, as height, vigor, etc., and then its influence is similar to that of environment; but it may sometimes affect the essential characters of varieties or species, such as external form, structure, etc., which become more or less blended into graft hybrids (228) or may disappear, giving place to new characters. Not only may the influence of the graft on the somatoplasm show itself directly in the grafted plants themselves, but it may produce an indirect reaction either parallel or not parallel to the direct reaction, and new characters may develop in the offspring, proving that, contrary to Weismann's theory, acquired characters can be transmitted in the vegetable kingdom.

From his theoretical considerations, Daniel deduces certain practical conclusions. When grafting does not modify the peculiar characters of a variety, but merely produces certain slight variations of nutrition, it may be employed to perpetuate varieties, races, or accidental forms of perennial plants; but if the influence of the graft on the somatoplasm is very marked and proves to be specific (which experiment alone can determine), it may be applied to the creation of new varieties. Here a new field of operation is opened up to seedsmen.

FIG. 146—WIRE PROTECTOR AGAINST MICE AND RABBITS

There are numerous practical applications of the reciprocal effect of stock and cion, such as increase in size of fruits, improvement of flavor of fruits and certain vegetables, production of new varieties in which color of flower, form of fruit, or vegetative organs are modified. The effects of grafting are more marked in herbaceous than in woody plants and also more marked in the off-

spring of the grafted plant than in the plant itself. Grafting, as a means of retaining variations acquired under culture, is useful only in the case of trees, and difference between seedling fruit trees and varieties producing them (199) may be explained in part by the effect of grafting on the progeny of the grafted plants.

Grafting which produces a variation in the seed may be used to produce new varieties. Since this variation can frequently be directed in a given way, it is possible almost to a certainty by repeated grafting to impart definite characteristics of flavor, form, color, etc., to plants which vary readily under culture. In other cases grafting may produce variations which, though hard to obtain, after once appearing, may be directed definitely.

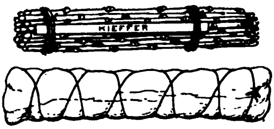

FIG. 147—BUNDLES OF CIONS FOR SHIPMENT

221. Asexual hybridization.—Formerly it was believed that grafted cions lost none of their own characteristics and acquired no new ones from the stocks on which they were grafted, but the experiments of Daniel and other investigators indicate that these views must be modified. For Daniel has proved that hybrids produced by grafting can be fixed and propagated true to kind, but he draws the conclusion that asexual hybridization is neither constant, regular nor very frequent. In its results it is somewhat similar to cross pollination, but has a wider application, and the resulting forms are less constant in character.

Grafting is not always a certain means of perpetuating variations, although it generally is. In itself it may occasion variation, which in turn may be fixed by grafting. In order to produce a given variation by grafting or to add to a plant a character it lacks, it is necessary to graft it on another plant which is superior to it in the quality sought. In grafting hybrid vines to secure a desired character, it is necessary to graft together two vines having common blood in such proportions that the sum of the blood of the characters desired shall be greater than the blood of any other strain in the graft. Modification in vines as regards eradication of the foxy flavor, increase in size of berry, resistance to exterior agents, etc., can thus be obtained.

The problem of the French grape industry, Daniel declares, is to unite American root resistance (to phylloxera) to the French quality fruit. He says this will probably be done, not by sexual hybridization alone, but by rational combination with asexual hy-

FIG. 148—PLANTING A BURLAPPED EVERGREEN

1. Placing the tree in the hole. 2. Removing the tier. 3. Removing canvas and adding soil. 4. More soil added for second man to pack around roots.

bridization by grafting, and then the preservation of the variation thus secured by budding.

Asexual hybridization, according to him, sometimes operates directly upon the grafted plants, sometimes indirectly upon the descendants; sometimes it affects external characters; sometimes it causes a disjunction of previously blended characters; sometimes heredity and persistence are complete; sometimes partial or lacking; often expected results can be secured. But the most important practical point is that in many cases grafting has served to insure systematic improvements of plants. Emphasis must be laid on his remark that *when a plant is to be improved in a certain respect, it must be grafted on a stock superior in this respect.*

222. Germplasm, the continuously living substance of an organism. It is capable of reproducing both itself and the somatoplasm, or body tissue, in giving rise to new individuals. It is the Substance, or Essence, or Life which is neither formed afresh, generation after generation, nor created or developed when sexual maturity is reached, but is present all the time as the potentiality of the individual, before birth and after death, as well as during that period we term "life" between these two events. The somatoplasm, on the other hand, has no such power. It can produce only its kind—the ephemeral, the perishable body or husk, which sooner or later completes its life cycle, dies and disintegrates. The germplasm, barring accident, is in a sense immortal.

223. Somatoplasm, the body tissues as a whole. See Germplasm (222).

CHAPTER XIII

GENERAL POINTS CONCERNING FRUIT TREE STOCKS*

224. Effects of stock on cion.—[With few exceptions] all fruit trees are consorts of two individuals, stock and cion. So far fruit growing has been carried on with little or no regard to their interactions. Yet there is no doubt that each reacts upon the other and that all grafted fruits are influenced for better or worse by the stocks upon which they are worked. To this fact those who have given the matter study now agree, though there is little accord in the explanations offered to account for the various effects. In short, about all we really know is that plants often get out of gear in the adjustment of cion to stock. Why and how, remain for the most part to be determined.

Since we cannot find clear-cut analyses of the effects of stock on cion, it is small wonder that fruit flowers give little attention to stocks. After centuries of fruit culture, we actually do not know what the best stocks are for many fruits. Further to complicate the situation, trees are profoundly modified by soil and climate, the modifications not infrequently being confused with those caused by the stock. Our fragmentary knowledge of stocks being thus a thing of shreds and patches, few are willing to break away from time-worn dictums, so continue to plant trees without attention to the reciprocal influences of stock and cion. Briefly, influences are as follows:

225. Influences of tree fruit stock on cion.—1. Stock modifies form and size. Altered size and form of tree resulting from grafting cannot be said to be due wholly to diminished vigor and not at all to debility. Rather, the cion takes the size, form and somewhat the peculiarities in habit of growth of the stock. Thus, the scraggly Red Canada apple worked on Northern Spy assumes, somewhat, not wholly, Spy characteristics of growth; pear on quince takes quince size; apple on Paradise or Doucin, the size and form of these stocks. Increased size rarely, if ever, occurs.

2. Adaptability of species or variety to soil may be changed by stock. Peach when worked on plum may do well on heavy soils where on their own roots they would be worthless. Conversely, plum can be adapted to light soils by working on peach, thriving still better on Myrobalan in most soils. Everything points to mazzard rather than mahaleb for both sweet and sour cherries. Ninety-

*Foot note: Paragraphs 224 to 233 are condensed from an address by Prof. U. P. Hedrick of New York, before the New York State Fruit Growers' Association.

nine trees out of a hundred are on maheleb stock as there is less loss. Cherry on mazzard should cost twice as much, but is worth the price. Mahaleb is sometimes better than mazzard in shallow or wet soil. Possibly this is the most inportant influence of stock on cion, for through it many fruits, which would not thrive, in some cases would not live, on their own roots, can be grown in unfavorable soils. The use of stocks to overcome soil adversities demands much more attention than has been given.

3. Through the stock, plants may be made to endure incompatible climates. It would be too much to say that hardiness as an inherent quality is transmitted from stock to cion, but it is very certain that increase in vigor imparted by some stocks gives greater hardiness to grafted plants. In the case of late-growing apples worked on Hibernal or Oldenberg stocks greater hardiness results, because the cion matures earlier than it would upon its own roots

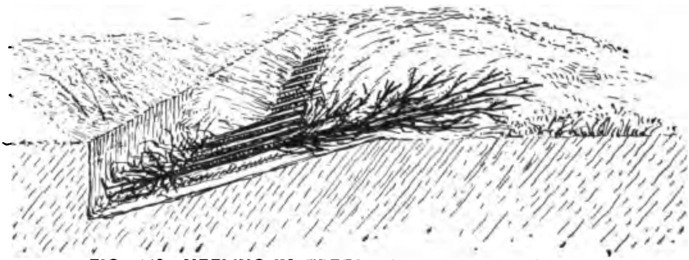

FIG. 149—HEELING-IN TREES FOR WINTER STORAGE

and is therefore better able to withstand the winter. Again, slight obstructions to the sap flow imposed more or less by union of different tissues of stock and cion may cause the cion to ripen earlier and thus bring about greater hardiness. Some plants, as peach, must have a warm soil; therefore, peach does better on plum in cold soils than on its own roots.

4. Stocks, if diseased, may impart the disease to cions, as when peach stocks infested with peach yellows or "little peach" are budded with healthy buds.

5. Productiveness of tree is often increased by stock, paradoxically enough, either by increasing or by decreasing plant vigor. Trees sometimes fail to fruit well because of too much wood growth, in which case grafting on less vigorous stocks checks growth and makes for productivity; thus we may explain the greater fruitfulness of some dwarf apples and pears. On the other hand, a fruit may be too weak in growth to be fruitful, hence grafting on a stock which imparts vigor may make it more productive.

6. Time of maturity of both wood and crop may be changed somewhat by stock—hastened on the one hand or retarded on the

other, according to whether stock ripens earlier or later than cion. It follows, of course, that keeping quality is affected in the same degree as maturity. From what is known on this subject we are warranted in saying that earliness is promoted only when the stock ripens its wood earlier than the cion; lateness, when the stock wood ripens later.

7. Color of fruit may be changed by stock. There is little evidence to substantiate the claim that the characteristic color of a fruit is changed by the stock, but, as all know, color is heightened by earliness and lessened by lateness in the maturity of a variety. In cases, then, in which stock influences time of maturity, color may be more or less changed. I know of a McIntosh orchard the fruit of which is much brighter in color and matures nearly two weeks earlier than McIntosh on standard stocks, apparently because grafted upon Oldenburg stocks.

8. Size of fruit is often increased by stock. I cite only pear on quince as an example. Many others might be adduced.

9. Stock affects eating qualities of fruit on cion. Larger, crisper,

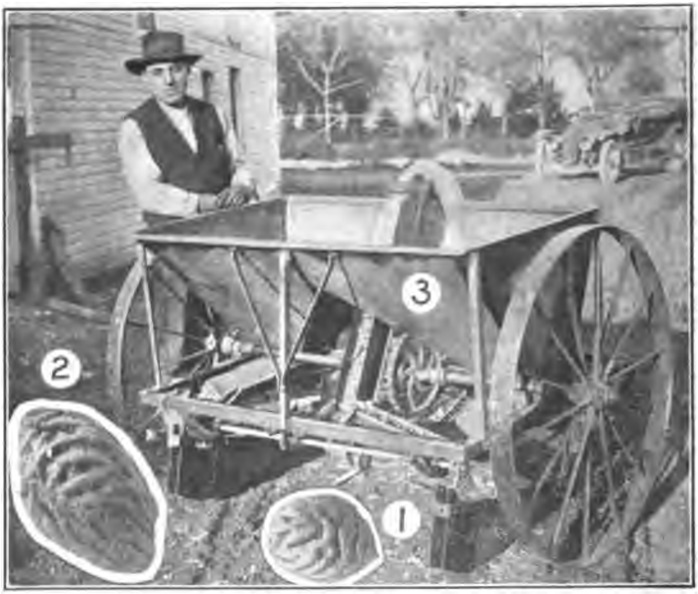

FIG. 150—PEACH PIT PLANTER

1. Natural wild peach pit; 2, Canning factory pit, not good for planting; 3, Hopper of machine. Most nurserymen contend for the "natural" pit as against pits of cultivated varieties secured from canneries.

juicier fruits of a variety can be grown on some stocks than on others, making them more palatable. Sweetness and sourness depend on amount of sugar and acid; these, in turn, are influenced by health, vigor, time of maturity and nutrition, all of which are influenced by stock. A variety may, therefore, be sweeter or sourer on one stock than on another. There is nothing to show that flavor is changed.

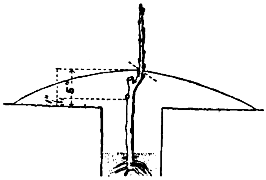

FIG. 151—GRAFT PLANTING

10. Some stocks shorten the life of the trees of which they are a part. Apples on pears and pears on apples are short-lived trees. Bartlett is short-lived when top-worked on Kieffer. As a rule, grafting weak-growing species on vigorous stock shortens the tree life.

226. Influence of grape stocks on cions.—Much more is known about influence of stock on cion in grape-growing than on tree fruits. To epitomize: Experimenters of established reputation hold that very appreciable differences may be noted between the chemical and the physical composition of grapes, grafted on various stocks and fruit of the same variety on its own roots. Among the effects claimed the following are quoted: Fruit of grafted vines is larger, has bigger seeds, thinner skin, berries are less numerous, juice is more copious, is usually both more acid and sugary, is less rich in phosphate, more highly charged with nitrogenous matters, has little tannin, less color and the color is less stable; vines are more fruitful; fruit matures earlier. These differences vary in different cases. In an experiment with grape stock for American grapes carried on for eleven years at the New York station material differences were found between grafted and ungrafted vines, all included in the above summary.

227. Influence of cion on stock.—Cion in its turn has a decided influence on stock. For example, the form of roots is much changed by the cion. Thus, in starting apples in a nursery we bud on seedlings which unbudded would have root systems much the same, but at digging time the roots of the various varieties are as

FIG. 152—NURSERY TREE DIGGER
The knife cuts the roots at 12 to 18 inches below the surface.

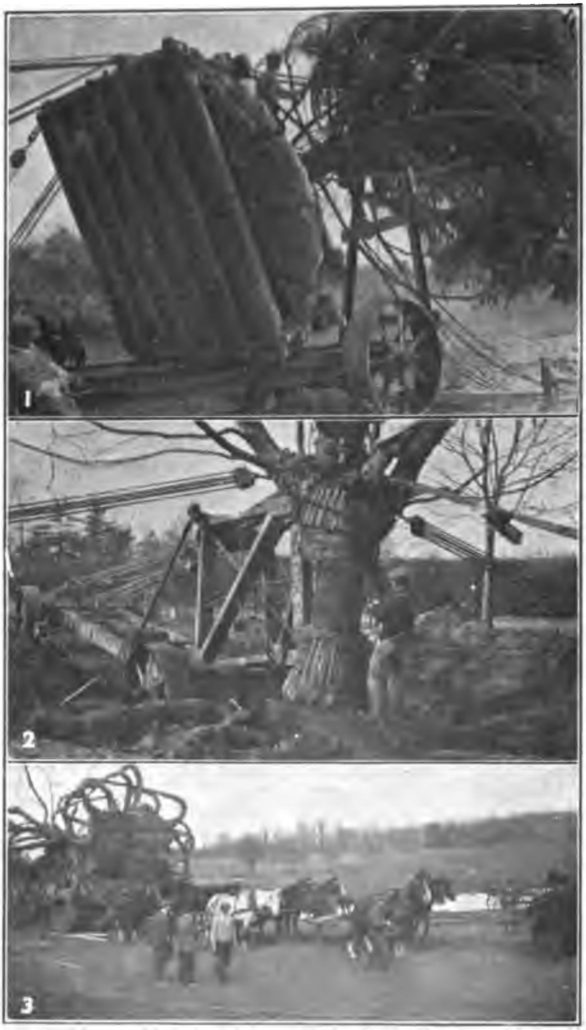

FIG. 153—MOVING LARGE TREES

1. Estimate size of tree by that of man above center of picture. 2. Notice the tackle and the size of the man. 3. Sixteen horses were needed to haul this tree.

diverse as the varieties themselves; Red Astrachan, for instance, has an exceedingly fibrous root system with few tap roots, while Oldenburg and Fameuse grown on either side of the Red Astrachan row, are almost destitute of root fibers, having instead deep tap roots with two or three prongs. Nurserymen declare the weaker the top growth and the sparser the foliage of a variety, the more deficient is the root growth.

228. Plant chimeras or "graft-hybrids."—To the general rule that stock and cion retain their identity there is a seeming exception in the pseudo-hybrids or plant chimeras of experimenters. When, after grafting, cion buds fail to grow and an adventitious bud arises at the junction of stock and cion, including cells from both parts, we have what for many years was known as a graft-hybrid, but is now more accurately called a plant chimera. In a case of this kind the cells from stock and cion reproduce themselves, sometimes the wood of one covering the other like a glove, or it may be the wood of the consorting pair grows side by side in parallel parts throughout the plant. These plant chimeras are more or less familiar in apples half sweet, the other half sour; or in which a portion of the apple is red or yellow and another russet. They are probably more often found in citrus fruits than in any others. It is possible that the cells of two consorting parts do actually blend in some cases, forming a true hybrid. Not improbably some of the many so-called strains of fruit described by those seeking to improve plants by bud selection are plant chimeras.

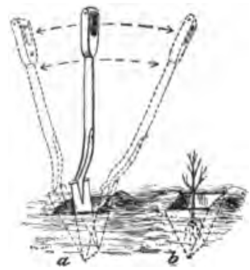

FIG. 154 — TRANSPLANTING IN LOOSE SOIL

229. Explanations for reciprocal effects.—Plant physiology does not help us much in elucidating the influence of grafting. Theoretically, from the anatomy of plants, we can expect nothing more in grafting than the adhesion of graft to stock. The tissues below the union are those of the stock; above it, those of the cion. Yet there is some reason to suspect that definite substances pass from one to the other in the consorting parts of a grafted plant and produce specific effects. Thus, when a cion with variegated foliage is grafted on a normal stock, shoots which spring from the stock below the graft are variegated. Or, if deadly nightshade be grafted on tomato, the poison, atropine, passes down into tomato root and stem. But curiously enough, if the variegated plant or the nightshade be used as a stock, variegation in one case and atropine in the other do not pass upward into the cions.

An ingenious and not at all improbable reason for some of the influence of the stock upon the cion was offered in the French Academy of Science [by Le Clerc du Sablon]. The speaker had

made analyses of pear trees two years old from the graft on quince and pear stocks to determine the relative quantities of plant foods stored in the stems of the two sets of plants. It was found that during autumn and winter reserve matter was markedly more abundant in the stem on quince stock. In spring, therefore, the pear on quince was enabled to furnish more food matter for fruit formation and crop production was greatly increased. Again, reserve food in stems is nearer the fruit than in roots and is thus possibly more readily utilized. If these experiments are accurate we may find the best stocks are those whose roots store the least quantity of reserve-foods and so force the accumulation of reserve matter in stems.

Unquestionably, some effects of stock are due to altered nutrition—possibly to insufficient nutrition of stock or cion. Much evidence points to disturbance of nutrition as the chief cause of the

FIG. 155—HERBACEOUS GRAFTING AND BUDDING

1, herbaceous buds; 2, herbaceous grafts. Summer methods of propagating grapes on green canes. None of the herbaceous methods so far tested in California have been very successful.

effects of grafting. It may be that food elaborated by the foliage of the cion is different from that the stock would have had with its own foliage. It has been suggested that difference in specific gravity of stock and cion sap may be a disturbing factor. But these explanations are not sufficient to cover all phenomena arising from grafting. Truth is we have for the most part only certain isolated facts to explain which we must rely upon inferences which have the greatest amount of probability in their favor from the knowledge of the case. It remains for someone to tell why.

230. Why nurserymen bud or graft trees.—Important though the effects of stock are on cions, any and all are but incidental to the true explanation for a two-part tree for practically all orchard plants. At the proper season in every nursery an army of expert workmen graft or bud so dexterously, precisely and rapidly that their work is little short of marvelous. What are the reasons for

all this seemingly extra work of grafting? Why do not nurserymen sell us plants on their own roots? In no other way can fruit trees true to name be propagated so rapidly. In some cases there is no other possible method of multiplying a variety. Unfortunately, the stocks chiefly chosen by nurserymen are those which can be worked most easily and soonest give a presentable nursery tree. [As a rule the seedlings of a species make the best stocks for that species.] Fruit growers, if they give the matter thought, choose stocks that do not sucker, or that best suit their soil and in a few cases one that will give a dwarf tree. All other effects of stock on cion are ignored by both nurseryman and fruit grower.

It does not follow, however, that whatsoever stock one wants can be used. Even when kinship is close some plants resist all appliances of art to make a successful union, while some distinct species of fruits seem foreordained to be joined. Thus, a pear will not grow well on an apple nor an apple on a pear, closely related though they are; but the pear readily unites with quince and hawthorn. So, too, peach and apricot are grafted on each other only with difficulty, but both readily unite with almond and plum. Sweet and sour cherries grow well on mahaleb cherry, but mahaleb will not grow on any of the cultivated cherries. Sour cherries upon sweet ones succeed less well than the latter on the former. The gooseberry will not grow on red currant, but thrives on black currant.

Something more is necessary, then, than botanical kinship, but just what no one knows beyond, of course, the knowledge that there must be some conformity in habit between stock and cion; that the two must start in growth at approximately the same time; and that the tissues must be sufficiently alike that there be proper contact in the union. Yet these facts do not sufficiently explain the affinities and antipathies which plants show. Thus, the propagator has little to guide him in selecting stocks and can choose only after making repeated trials, near relationship being the only guide, even though often an untrustworthy one.

231. Influence of stock propagation method.—Not only are grafted plants affected by kind of stock used, but also by manner of propagating stocks, whether from seed or from cuttings. There is no question, for example, that stocks propagated by cuttings do not produce the deep tap and prong roots that seedlings do. Again, seedlings lifted and root-pruned the season before budded or grafted have thicker root systems than if not so transplanted.

It seems necessary, therefore, to say that for the best interests of fruit-growing we cannot neglect the way in which stocks are grown. Undoubtedly for some conditions we shall find stocks from cuttings preferable; under others, and generally, seedlings will be better when we have a choice. So too, usually, when nursery practice permits, a stock is better for having been transplanted before budding or grafting.

232. Pedigreed trees.—The selection of stocks leads straight to the center of another problem. We hear much about the in-

dividuality of orchard trees and the necessity of propagating from individuals having the best characters. The speaker does not believe in "pedigreed trees", finding but little in either theory or fact to substantiate the claim of those who believe they can improve varieties by bud selection. The multitude of trees in any variety, all from one seed, it seems paradoxical to say, are morphologically one individual. A plant variety propagated by buds is essentially complete in its heredity. How, then, can the difference between individual plants in every orchard be explained?

Ample explanation is found in "nurture" without invoking a change in "nature." Soil, sunlight, moisture, insects, disease—and, more than any of these, the stock—give every individual plant an

FIG. 156—HAND METHOD OF PLANTING NURSERY STOCK

Two men work to better advantage than one alone.

environment of its own from which come characters which appear and disappear with the individual. Thus, it is believed, we can bend a variety by means of a stock, but not that we can permanently mold it into any new form given it by a stock. Let go the force, whatever it may be, which bends the variety and it snaps back into its same old self.

233. Necessity for stock breeding.—In the coming refinement of fruit growing we must breed stocks as we now do varieties they support. The stocks of all tree fruits are supposed to be seedlings of cultivated varieties. Yet only a cursory investigation at home or abroad shows that seed from cider presses and stone fruit pits from canneries are commonly used in growing nursery stocks. Under present methods it is mere chance as to whether one gets a tree on a good, or a bad plant on any stock. Would it not be a safe stroke of business for a nurseryman to select his stocks and through his catalogue educate fruit growers as to the greater value of trees on good stocks?

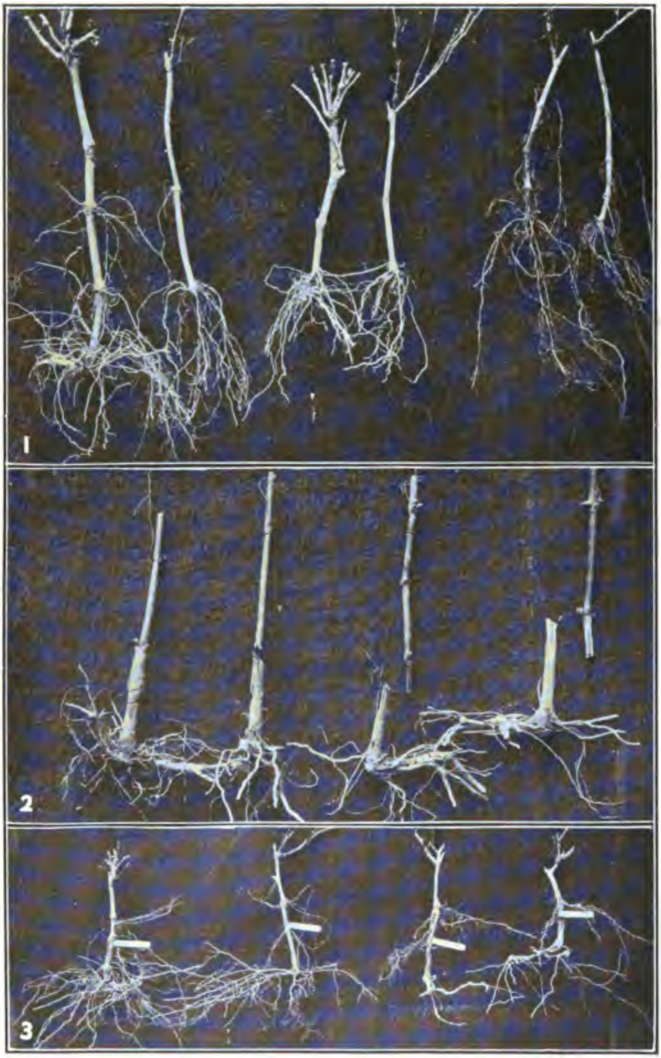

FIG. 157—GRAPE GRAFTING

1, rooted stock vines; 2, grafts in inverted order, reading right to left: cion, stock (two specimens of each) parts fitted, completed graft. 3, rooted cions. The roots produced above the labels are from the cions. They should be destroyed.

234. Pedigreed trees again (see 232). J. P. Stewart discusses this question in a recent bulletin, condensed as follows:

Various theories of observation have been advanced, but only a few experiments conducted. The net results of observation and discussion, however, have shown merely that important variations do exist among mature apple trees, in almost any direction desired, but thus far none of the variations within a variety, with the apparent exception of color, have been actually proved to be heritable. In addition the most fundamental and generally accepted theories are all against such inheritance, without excepting color.

With this situation in view, a preliminary test was started at the Pennsylvania Experiment Station on the influence of cion selection in improving yields. The individual trees were chosen merely on the recommendation of commercial growers, for the most part, and without any definite and comparative records covering several years—the only satisfactory basis for making the primary determination of what are really superior individuals. This defect is being remedied in another more comprehensive test recently started. In the present test cions from supposedly superior individuals were top grafted chiefly on Northern Spy stock. Ordinary nursery trees of the same variety were planted alongside for comparison.

It is much too early to draw conclusions from this work, but the results to the close of the seventh year indicate that in four of eight varieties, a slight superiority is shown by the trees produced from the selected cions. In three varieties no advantage is shown in either group, although the cions for these trees were secured from one of the most prominent advocates of the practice; in the eighth a slight difference favors the nursery trees.

The results are evidently insufficient either to approve or condemn the practice of cion selection. Such trees may have more certainty of trueness to name where the cions have come recently from the pure trees of known bearing habits, and one is naturally on the safe side of the question in using them, when they can be obtained without material difference in price. This, however, is all that can be said at present in favor of the practice so far as apples are concerned. Much more data are needed.

235. Stocks in top-grafting.—In case experiments should definitely prove cion selection to be advisable, it may be well to know something of the relative values of various stocks available for top-grafting. It seems also that some desirable varieties should regularly be top-grafted to secure better and healthier trunks. To secure data on the relative merits of certain well-known varieties for stock purposes, a test has been started at the Pennsylvania station, using four trees each of three varieties top-grafted on five different stocks. Stewart's progress re-

port is somewhat condensed from a recent bulletin as follows:

One rather unexpected result so far is that in all cases except one (Wolf River) the trees top-grafted on known stocks have made a better average growth than those grafted on seedling roots in the nursery. All top-grafted Grimes trees are also in the lead. Among the various stocks, trees developed on Paragon are distinctly in the lead, with those on Tolman second. With Grimes and Tompkins King, the only varieties of these three that really need top-grafting, the superiority of these two stocks is very marked so far as growth is concerned. In smoothness of unions, Tolman and Champion are probably best, with Paragon next, if the top-grafts with Jonathan be excepted, as with that variety the Paragon stock has tended to outgrow the cions. Incidentally, the reverse is the case with Grimes on Wolf River.

FIG. 153—NEGRO WOMEN ARE LARGELY EMPLOYED IN SOUTHERN NURSERIES

Northern Spy stock has averaged third in growth and is now running about equal to Paragon in unions. It also usually makes an excellent trunk and root system, but in at least one respect it is considerably less desirable than either Tolman, or Paragon for stock purposes; namely, in its unusual tardiness in starting growth in spring. This tends to make the cions more active than the stocks of most varieties, naturally the reverse of the condition desired when grafts are being started. From present results, therefore, either Paragon or Tolman appears to be distinctly preferable to any of the others, for Grimes at least—Champion third, if Jonathan grafts are omitted.

Samuel Fraser of Geneseo, N. Y., finds that Twenty-Ounce top-grafted on Baldwin makes 50 to 100 per cent better trees in five to eight years than when worked on Northern Spy. Similarly, Wealthy does poorly on Rhode Island Greening, while the latter does well on Wealthy. Hubbardston cions grafted on Ben Davis, Northern

Spy and Tolman resulted in such peculiar changes in twig color—some becoming red, some purple, etc.—that they could not be used with safety for further cion wood until they had proved their identity by coming into bearing.

These and similar facts indicate that many common variations in size and vigor so frequently shown by the same variety of tree,

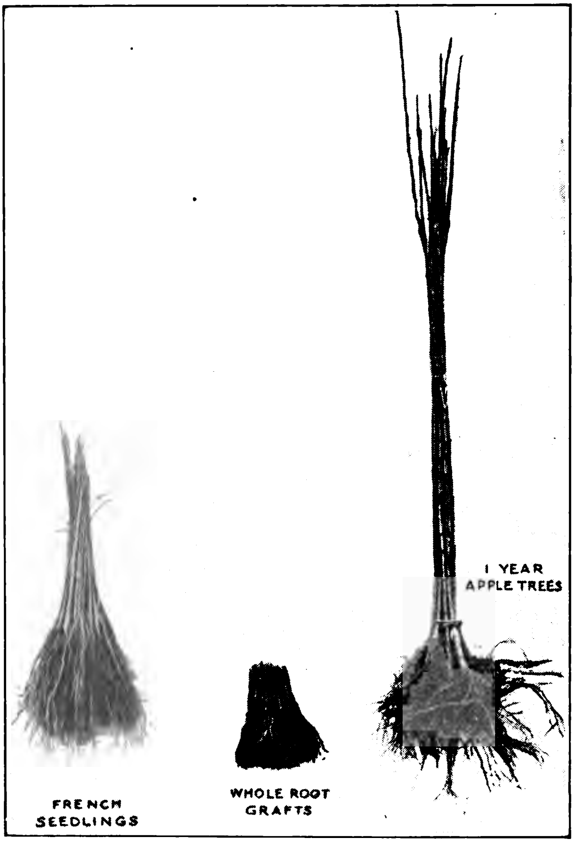

FIG. 159—STAGES IN GRAFTED APPLE TREE PRODUCTION

Notice that the finished trees are "whips." These are what commercial planters are largely preferring to two year trees because they allow the head to be formed at any height and they grow better than the older trees.

both in nursery and later growth, are due to differences in congeniality between the cions and the variable seedling stocks.

236. Hardy stocks for tender varieties.—At the Canadian experiment farms 90 varieties of apples were top-grafted on hardy stocks to see if they could thus be made hardy, but practically all were killed back to the stocks. One Wealthy stock grafted to Milwaukee and Martha carried the former through a very severe winter and matured a crop of fruit, while the latter was killed. Hence the conclusion: Trees tender on their own roots are also tender on hardy stocks.

237. Slow-maturing stocks (Northern Spy), according to Gulley of Connecticut, do not delay the fruiting of quick-maturing varieties (Jonathan and Canada Red).

238. Quince effect on pear.—Two French investigators, G. Reviere and G. Bailhacke, tested the effects of stock upon cion of two pear trees of one variety upon quince and pear stocks respectively. The trees were 15 years old and had grown under apparently identical conditions. For three successive seasons the fruits were collected; samples were analyzed, etc. Each bore about 300 fruits annually. Those on the pear stock were green, those on quince yellow with a rose blush on the sunny side. The average weight, density, acidity and sugar content were in favor of the quince stock. Observations on another variety tallied with these findings. The differences are attributed to greater activity of the chlorophyll in the quince case.

239. Hardness and softness of wood in apple grafting.—E. Leroux, a French investigator, has concluded from experiments with 200 varieties of cider apples that (1) varieties with tender wood can be most successfully grafted on tender-wooded varieties and hard-wooded on hard-wooded; (2) success follows only rarely when a tender-wooded one is grafted on a hard-wooded one; (3) success seldom or never follows when a variety with hard wood is grafted on a soft-wooded stock. These principles are believed to apply to other orchard fruits.

240. Effect of small growing stock on cion.—Booth reports an instance in which peaches on Mariana plum stocks grew fairly well for two years, though from the start the peaches grew much more rapidly than the plums, so the peach trunks were at two years twice as large at the union as below. During the second season the weather was very hot and dry, and the peach trees after wilting for several days but reviving during the night, finally dried out and died, evidently because sufficient moisture was not furnished by the slow-growing Mariana roots to meet the demand from the peach leaves during a period of

excessive transpiration. "While such an instance is uncommon, there is but little question that the amount of growth will always be lessened, the life of the plant will be shortened and it will withstand adverse conditions less readily when the stock plant is noticeably slower in growth than the cion plant."

241. Pears on apple stocks.—A writer in *American Gardening* claims to have grown Flemish Beauty pears on Wagner apple stocks. The pears were larger and of finer flavor than those on the mother pear tree and were free from brown specks. The grafts bore every year for six years without a break, while the mother tree failed some years and the apple tree bore only biennially.

Camperdown, a weeping elm, when grafted on European elm (*Ulmus scabra*) stocks "weeps" from the point of union, the top being more or less flat at first; but when grafted on American elm (*U. Americana*), it grows upright and very tall, because the vigor of this stock overcomes the weeping habit to a large extent.

FIG. 160—LARGE TREES ARE CONVENIENTLY HANDLED BY TRUCK

CHAPTER XIV

STOCK AND CION HANDLING

242. Own-rooted trees are those produced either from seed, cuttings or otherwise than grafting or budding, so they have roots of the same wood as their trunks. Grafted and budded trees are said to become "own-rooted" when they have developed roots from the cion above the union and the stock ceases to function. Grafted grapes, roses and other plants often become own rooted in the same way. In certain cases it may be an advantage for grafted trees to become own-rooted, as in the northwestern states, where the winters are severe and only hardy roots can withstand the rigors. In other cases it is a disadvantage; for instance, dwarfs which would thus become standards. Again, if own roots are allowed to grow on cions of European grape grafted on phylloxera-resistant American stocks, the vines would be as open to attacks of this insect (280) as if not grafted.

243. Standard is a term applied to trees which grow the full, normal size of the species upon their own roots or the roots of a stock which does not dwarf them.

244. The production of seedlings is a branch of the nursery business for the most part in the hands of specialists who sell their product to other nurserymen for budding and grafting. The former men usually are not concerned with the work of the latter and vice versa.

245. Apple seedlings to be used as stocks require a deep, fertile soil such as that in the Kaw Valley of Kansas, where the rich black earth produces long, straight, plump tap roots. Hard, gravelly and shallow soils over hardpan contort the tap root and produce branches, thus spoiling the seedlings for stock purposes. Long, plump, unbranched tap roots make two or three or even four stocks. The ground is deeply plowed and loosened to 10 inches if possible, preferably in the fall, so it may be worked at the earliest possible moment in spring.

The seeds stratified (49) over winter, or imported in late winter, soaked for three days with changes of water twice daily and then stored between ice cakes in canvas bags, are sown as soon as the ground can be handled. This is essential because they sprout at a very low temperature, and to sow sprouted seed means a poor stand of plants. Rows are made three or four feet apart, the seeds dropped an inch asunder and covered an inch or less deep. In wet land, rotted sandy compost or other loose material is often used. Cultivation is the same as for garden vegetables. When the leaves have dropped in the fall, the seedlings are dug with special implements, which save nine to twelve inches of root. Part of the top is usually cut off, the seedlings tied in bundles of 100 and stored in green sawdust till needed.

FIG. 161—SPADING IN NURSERY STOCK

246. Apple stocks.—For standard apples French crab and Vermont crab seedlings are most popular; for dwarf and semi-dwarf apples, French Paradise and Doucin trees respectively, grown mainly by means of stools; that is, mound layers. Of all these, French crab is most popular in America. Some nurserymen import the seed and grow their own seedlings, others buy abroad whenever they can get suitable material; still others have formed a company which grows the stock in France and distributes the product to its members. Immense quantities of stock are grown in the central western United States, notably Kansas, and sold to nurserymen for root grafting. Both French and Vermont seeds are used.

247. French crab stock defined.—French crab seed is produced by the natural or wild apples used in France

for cider making. Seeds from cultivated apple trees are considered inferior and when mixed with wild crab seeds reduce the value of the sample. The seed, washed from the pomace at cider mills and on farms, is dried in the open air. Normandy is the leading source of the seed.

In early winter the nurserymen mix the newly secured seed with sifted river sand and store the boxes in sheltered places, such as stables and outhouses, care being taken to prevent attacks of mice. The sand, kept moist, is stirred occasionally. When the seeds begin to swell (in about a month), they are either placed in cold frames or sown in the field. In the former case the seedlings are transplanted. Three or four weeks are needed for germination. Lukewarm water, used by some growers, hastens germination, but is considered inexpedient by many. Some growers soak the seed 48 hours before planting, but the plan is not widely popular. It is used only when the season is precocious and hastened germination seems necessary.

FIG. 162—FIRST PRUNING OF BUDDED TREE

Stock top and pruners in center. Budded tree at right.

French layers (Fig. 55) of Doucin and Paradise apples are cut from the parent plants in the fall and either sold that season in spite of their small roots or they are transplanted and grown in nursery rows the following year to make vigorous plants. The latter cost more.

248. Vermont crab stocks are grown from seeds gath-

ered at New England cider mills. Formerly most of the apples used were apparently seedlings, but seed of cultivated varieties has been finding its way into the commercial seed in increasing quantities, due to the dying of seedling trees and the increase of cultivated varieties, the culls of which are used for cider. Seedling growers are of opinion that stronger stock trees can be grown from seedling than from budded or grafted trees. Hence Vermont seed is losing its reputation, partly on this account and partly because the seed comes more and more from decrepit trees and cull fruit. At the present writing most Vermont seed is used in the Northern and the Western states, while French seed dominates the middle West and the East.

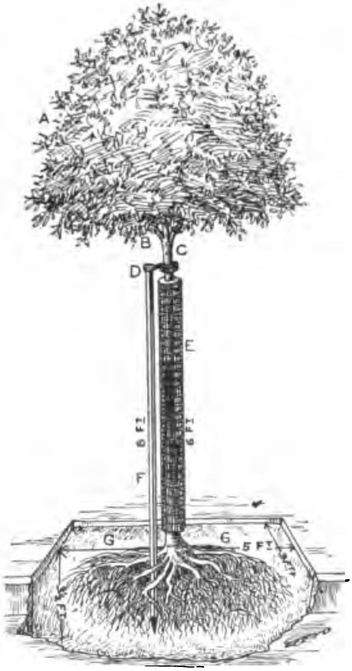

FIG. 163—STREET TREE SPECIFICATIONS

A, character of top; B, height of lowest branch; C, character of trunk; D, burlap to prevent barking; E, wire netting protector; F, stake to hold tree till established; G, character of roots.

249. Paradise and Doucin stocks for dwarf trees (252) are at present of small importance in America, because dwarf trees have here not come into anything like the prominence they play in Europe, but the demand for them is increasing, more especially in New England.

250. Securing apple seed. — In growing apple trees Hansen of South Dakota has found that the seed should be separated from cider pomace before planting, since fermentation acts injuriously. Clean seed washed

from pomace within 24 hours of pressing should be spread out to dry for a day or two, then mixed with moist sand and buried in well-drained sites in small boxes with holes in the bottoms for drainage, and left over winter. He has been most successful when the seeds were planted in beds four feet wide, surrounded by 12-inch boards and given lath screen shade as soon as the seedlings begin to appear.

251. Dwarf apples.—Hedrick of the New York State station reports a ten-year experiment with dwarf apples. That part of the summary which deals mainly with the results of propagation is slightly condensed thus:

The results show: 1. That the union between stock and cion is poorer with Doucin and French Paradise and with French Crab, and that varieties unite less well on French Paradise than on Doucin stocks. 2. Doucin and French Paradise stocks are less hardy than French Crab; and of the two dwarfs, French Paradise is much less hardy. 3. The greatest weakness of dwarfing stock for New York is surface-rooting, in which character the two stocks cannot be distinguished. Evil results following surface rooting are winterkilling, uprooting of trees by wind, suckering and injury in cultivation. 4. Suckers from both dwarfing stocks prove much more troublesome than with standard trees. 5. Trees on the three stocks attained the size commonly ascribed to them; those on French Crab, full size; on Doucin half dwarf; on French Paradise, true dwarf. In this test the dwarfing effect of dwarf stock is not as marked as is commonly reputed.

252. Dwarfing trees to be grown in the open requires that cions or buds be worked on slow-growing stocks and later headed in. Plants may also be dwarfed by growing them in confined quarters, such as boxes, tubs and pots too small for their normal development. Nurserymen can go no further than supplying the specimens; after care depends upon the grower, who by neglect or ignorance may develop standards from those intended to be dwarfs.

When grafted or budded "dwarfs" are planted so deeply that roots are developed by the cion above the union with the stock, the tree will become "half dwarf" or even "standard." Such roots must be cut off from time to time as they develop. Dwarf cherries are grown on mahaleb stocks, but so are probably the majority of standard cherry trees. Annual removal of roots from the cion and heading-in will keep the trees dwarf in habit.

So, too, of plums upon myrobalan, and apples upon Paradise and Doucin stocks.

253. Quince stocks of an inferior crder are grown from seed. Large quantities of good ones are produced by stools or mound layers (94), but the great bulk is now grown from cuttings, especially in the neighborhood of Angers, France. Nurserymen who have tried other stocks give this the preference. Dwarf pears are more often budded than grafted on quince stocks.

254. Pear on quince produces larger fruits and bigger yields than on pear stock. LeClerc du Sablon attributes these phenomena to the greater accumulation and reserve food during fall and winter in the trunk and limbs of the pear-quince union. This food in spring helps form fruits in larger quantity and of greater size. No reason is assigned for the larger starch accumulation.

255. Kieffer pear is so strong a grower that attempts to dwarf it result either in the cion taking root, thus making the tree a standard, or in the top outgrowing the stock so much that the union, being poor, the tree easily breaks off.

256. Double working is sometimes employed to make a straight tree instead of a straggling one (Winter Nelis pear) or to give vigor to one that grows weakly or poorly (King and Grimes apples—subject to collar rot). The strong grower is first grown upon a seedling stock, and when old enough grafted or budded with the desired variety, thus performing two graftage operations and having three different kinds of wood—that from the seedling, and that from the second bud or cion upon the first. Generally the first cion is allowed to grow a year before the second is grafted on it; but sometimes when the "sandwich" of intermediate wood is to be short, as with pears, both are set together; that is, a cion of the desired variety is grafted in the cion which is to produce the intermediate wood, and this one then inserted in the seedling stock. Considerable skill in grafting is needed to offset the extra risk of failure by this plan.

The trees most often double worked are probably pears, some of which do not form good direct unions with quince stocks, and which must therefore have a go-be-

tween stock which does make a good union, both with them and with quince. Among varieties usually treated this way, the following are perhaps best known: Bosc, Winter Nelis, Sheldon, Washington, Marie Louise, Gansel's Bergamot, Josephin de Malines, Dix, Dunmore and Paradise. These are worked on one of the varieties that do make better unions on quince than on pear; for instance, Angouleme, Louise Bonne, Vicar, Glout Morceau, Easter, Diel, Amalis and Autumn Long Green. Always in double working dwarf pears both operations must be as near the ground as possible, so only an inch or two of the first pear wood shall be left when the double work is complete. Popular apple "go-betweens" are Northern Spy. Tolman, Ben Davis and Delicious. Among plums Lombard is perhaps most in favor.

FIG. 164—TRIMMING AN ORNAMENTAL TREE FOR FORM

This tree may be sold when 25 or 30 feet tall.

257. Origin of pear stocks.—Pear seed is secured in France from the perry (pear cider) presses. It is several times as expensive as apple seed, because each seed must be picked from the core by hand. Most pear stocks used in America are grown in France. Our nurserymen prefer them because they are started in seed beds and transplanted while still small. This tends to make their roots

branch and to make them superior to untransplanted stock, both for budding and grafting. Many American nurserymen consider Japanese stocks stronger than French ones, but French nurserymen won't use them because fruit growers there are prejudiced against them. Some pear seed, chiefly from Kieffer trees, is collected in Maryland, Delaware and New Jersey canneries and used in the United States, but nurserymen consider seed from Japan to be better. Though most of the Japanese pear seedlings are imported from Japan, some arrive from Holland and France.

FIG. 165—BUNDLE OF WHOLE ROOT GRAFTS

These are about 9 inches long, the most convenient length for handling

258. Pear propagation.—Standard pears are generally propagated by whip grafting (305) on whole stocks at the crown. Only a small part of the lower end of the tap root is cut off. The cion is shorter than in most apple grafting—about four inches. Waxing is necessary. When this is done indoors, and when the wood is fairly warm, injury from the warm wax is avoided by dropping the grafts as waxed into cold water, after which they are made into bundles and stored like apple-root grafts. Greater care is needed in planting because of their length. Larger percentages of these grafts will grow than would in the case of ordinary root grafts in which the loss is counted at about 50 per cent.

259. Spring-budding pears. — In Maryland Japanese seedling pear stocks were placed in a hotbed in early April in six inches of sand. The manure and sun heat made the sap start so that in eight days the stocks were ready to bud by the ordinary method. They were taken to a warm room, budded with Mikado pear buds and placed back in the sand to "take." In about eight more days, all having taken nicely, they were transferred to damp sawdust to prevent further growth till they could be set in the nursery a few days later. During summer, under good culture, they grew about two feet, and by fall were large enough to transplant in orchards. The method is practicable on a large scale.

260 Peach stocks are secured from seeds usually stratified the previous winter and sown in spring. Seed considered best comes from seedling trees in the mountainous parts of the Carolinas and adjacent states, Oklahoma and Arkansas. Pits from the canneries are not favored by some nurserymen, but are extensively used by others.

FIG. 166 — GRAFTED CHESTNUT BEARING AT TWO YEARS

Pits are sometimes planted in fall in nursery rows, but since seedlings may have difficulty in breaking through the soil in spring, this plan is not generally popular. Usually the pits are stratified as soon as received in fall or early winter, the object being to have them freeze and split. On a small scale stratifying may be in shallow boxes of sand or soil, but, on a large scale, basin-like pits large enough to hold several bushels are made in soil. Earth is thrown over the seeds and kept moist or frozen all winter. If planted without being stratified only a small percentage of seeds will sprout the first season, the balance continuing the following year or two.

261. Plum stocks.—Nurserymen differ widely in their preferences of plum stocks, depending mainly on cost, ease of working, and adaptability of cion to stock. Myrobalan is the leading general purpose stock, though

Japanese and peach are often preferred for sandy soils, Americana for American varieties and St. Julien, though costly, for Domestica and Insititia. Mariana is still used in the central southwest, but in most other sections is unpopular because it makes poor unions.

In Europe, myrobalan is considered a dwarfing stock which produces short-lived trees; in America it is widely preferred because it produces larger and finer two-year trees than do other stocks. In the South, however, it suckers badly, and in the prairie states it winterkills. Its cheapness, ease of budding and general perfection of unions are strong points. Because of its variability there are many "true" and "false" mybrobalans among nurserymen. Formerly stocks in France were grown from cuttings; now apparently from seed.

St. Julien has been claimed to produce longer-lived, thriftier, hardier, deeper-feeding trees which sprout less than those on other stocks; but its cost, hardness to bud, poor growth and liability to fungi in the nursery are against it. Horse plum is now "wholly superseded."

Peach is largely used for many varieties of plum to grow on warm, sandy or gravelly soils. It conduces to quick growth and early bearing and the roots produce no sprouts. Budding is easy, the trees make vigorous nursery growth, probably at less cost than on any other stock. Japanese varieties do especially well on peach. For Domestica and Insititia varieties it is not so valuable because of poor unions and tender roots. Varieties said not to unite well with peach are: Lombard, Damson, Yellow Egg and Washington. Peach borers are sometimes troublesome on peach stocks.

Mariana appeals more to nurserymen than to fruit growers, because it readily strikes roots from cuttings, and nursery growth is ideal. Growers favor it less than formerly, and it is declining in popularity because it has a dwarfing effect and is prone to sucker.

Americana seedlings are the only ones that will with-

stand the rigorous northwest winters. They are used only for native varieties. It is not known how successfully other plums can be grown on them, though W. & T. Smith of Geneva, N. Y., report their use as satisfactory. As yet they are expensive, so they are not likely soon to compete with myrobalan and peach stocks. Their chief fault is their suckering habit.

Munsonia is reputed to be "pre-eminently adapted for low, wet lands." Kerr believes *P. hortulana* excellent because it never suckers. *P. Angustifolia,* var. *Watsoni* promises to be a dwarfing species. *P. bessyi,* according to Hansen, also dwarfs varieties worked on it, but is hardy

FIG. 167—"SPROUTING" BUDDED NURSERY STOCK

Men standing are foremen; men kneeling are removing all branches except the bud shoots.

and produces precocious and prolific trees. For topworking Domestica, Lombard is probably best. The sooner done the better because slow and crooked growth is common with late working. Early spring grafting and late summer budding are best.

262. Cherry stocks.*—Despite the antiquity and the importance of the cherry, the question of stocks is unsettled. Fruit growers favor mazzard; nurserymen, mahaleb, which they consider fit, at least, for sweet, and best for sour kinds. Further, they say it is impossible to grow cherries on mazzard at prices fruit growers are

*Synopsized from *The Cherries of New York* by Hedrick.

willing to pay. No systematic attempts have been made to settle the controversy.

The mazzard or wild sweet cherry (*Prunus avium*), used for centuries as a stock, grows 30 to 40 feet tall with trunks often 18 inches in diameter. In America it is tender to cold, but grows vigorously. Its seedlings, imported from France, are badly attacked in nurseries by fungi, but it produces uniform trees and fruit.

Mahaleb (*Prunus mahaleb*) is a thick, slender-branched bush with inedible fruits, differing markedly from both sweet and sour cherries. The wood structure "one

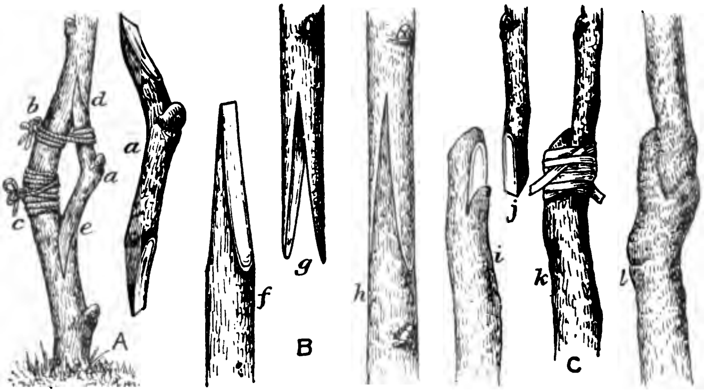

FIG. 168—THREE UNUSUAL STYLES OF GRAFTING

A, bow grafting of vine; a, cion; b, ligature to increase pressure of cion to stock; c, tightly wound ligature to check sap flow; d, e, slits for insertion of cion. B, saddle graft; f, stock; g, cion; h, parts fitted together; C, veneer graft; i, stock; j, cion; k, parts fitted and tied; l, graft after union.

would expect to differ very materially" from that of sweet and sour cherries so that even if the union proved normal there would be difficulty in the passage of solutions between stock and cion. This cherry is propagated almost wholly from seed, though it may easily be grown from layers, cuttings and suckers. The American supply comes from France. Mahaleb seems to have been used in the United States since about 1850, first as a dwarfing

stock but now for all purposes. Probably 95 per cent of our cherries are budded on it. Why?

Doubtless it is easier to make better-looking nursery trees on mahaleb than on mazzard, and it is cheaper. Mazzard has the faults of its species—capriciousness as to soils, climates, cultivation, pruning, diseases and insects; mahaleb is adapted to wider range of soils, is hardier to heat and cold, less particular as to tillage, will stand

FIG. 169—UNPACKING AND HEELING-IN NURSERY STOCK

This work should be done immediately on arrival of stock, unless trees are in prime condition and can be planted at once. If shriveled or dry the trees should be soaked in water two or three days before planting.

more pruning, is less susceptible to insects and is not badly affected by shot-hole fungus. It is more easily worked, both as to actual budding and to length of season. It also ripens its trees better and may thus be dug earlier than trees on mazzard.

Fruit growers in their turn find trees on mahaleb stocks hardier, though not as hardy as might be wished;

more dwarf; more precocious as to bearing; as good as to size of fruit borne; poorer in union than mazzard; better adapted to diverse soils, especially light ones; also to shallow culture; shorter lived; less productive and profitable under equal conditions of soil and climate than trees on mazzard, this last being the consensus of opinion among the great cherry regions of California, Oregon, Washington, Michigan and New York.

263. Other cherry stocks.—Few fruits have such a wealth of other stocks to choose among, yet have been tried so little. Russian cherries, come fairly true from seed, and make good orchard plants on their own roots. Only sour kinds should be used—Bessarabian, Brusseler Braune, Double Natte, George Glass, Lutovka, Early Morello, Osthein and Vladimir. These, it is believed, would have some dwarfing effect. Ostheim and Morello have been used successfully in the North Mississippi Valley. Bird, pin or pigeon cherry (*Prunus pennsylvanica*) is often used as a hardy stock for cold regions and as a makeshift, since it dwarfs the trees and suckers badly. In the Northwest the sand cherry (*P. pumila*) is used in cold, dry regions for sour cherries. It is as easy to work as mahaleb and its seedlings are large enough to set in nursery rows the following spring for August budding. Winter-rooted cuttings set in the nursery with two to four inches growth can also be budded in August. This species has made good unions with hardy cherries by budding and does not dwarf the trees more the first five years than does mahaleb. In Japan the Dai-Sakura, supposed to be a variety of *P. pseudocerasus,* grown by nurserymen from mound layers and cuttings for stock, has a somewhat dwarfing influence on European cherries. It should be tried in America. Among the many other stocks available some have already been introduced by the United States Department of Agriculture. Probably several of these or the others mentioned, will prove better than mazzard and mahaleb.

Cherries are usually budded; they may be more or less

easily root grafted, though perhaps not as profitably. Whole roots are generally used, the union being made at the crown. In the cold Northwest the work is done with the intention of making the trees own-rooted.

Cherry buds are generally taken from nursery stock. Apparently varieties do not wear out, since old kinds have lost no characters accredited to them, even centuries ago; nor does taking buds from vigorous, mature trees or even decrepit trees seem to make a difference—all alike produce the variety. Hence, the hypotheses that fruit trees degenerate and that they may be improved by bud selection finds no support in the cherry.

264. Cherry grafting.—At the Canadian Experimental Farms root grafts of Morello on commercial stocks gave poor results; crown grafts good ones. For budding, the bird cherry (*P. pennsylvanica*) gave so much sap that buds did not unite well.

265. Cherry grafting and budding.—Cherry cions, according to a writer in the *Gardeners' Chronicle,* should be cut at least two months before grafting and buried in a sheltered frost-proof place. Established stocks are budded in July, not at the base, but at the exact height of the head. Stocks that fail to take are grafted the following spring, when the stocks are headed back as close to the ground as convenient and whip grafted, cions being about five inches long, bound with raffia and covered with prepared clay

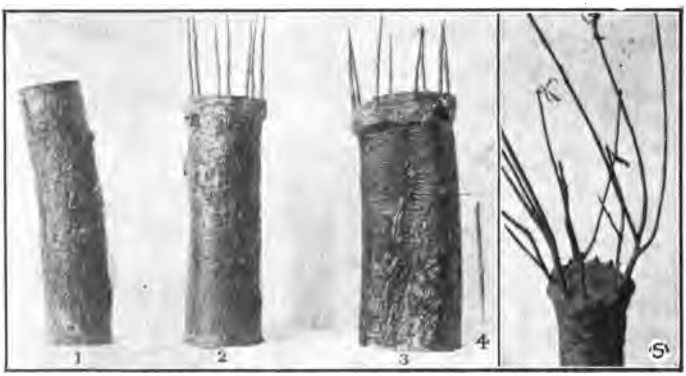

FIG. 170—BARK GRAFTING IN VARIOUS STAGES

1. Stock. 2, cions set and tied. 3, cions waxed. 4, cion. 5, results; all but two cions grew.

(clay and fresh horse manure). A point is made above and below the bandage to shed water. In less than a month the buds should start. The shoots are brittle and need staking.

266. Rose stocks are sometimes grown from seeds sown as soon as ripe or stored in the hips till spring; hardy species outdoors, tender ones under glass. Layers and root cuttings are often used, but semi-mature stem cuttings from forced plants in midwinter under glass are most popular. Manetti and multiflora stocks imported

FIG. 171—TREES STACKED IN FROST PROOF NURSERY CELLAR
This is the plan followed by the largest nursery companies of the North

from Europe are most popular. In America the former are most widely used. They must have their buds removed to prevent sprouting, which they will otherwise surely do. Budding in America is done close to the ground, but in Europe the popular "tree" roses are made by inserting the buds at three or four feet. Multiflora is a producer of quick results. Its spring-made cuttings are ready for budding in six months. Home-grown seedlings usually require two years to reach budding size.

Winter grafting with dormant wood makes good pot plants of hybrid perpetual varieties. *Rosa rubiginosa* (sweet briar), *R. watsoniana,* and several other species are used to some extent. Usually the shield method of budding, but sometimes veneer grafting, is employed.

267. Hybrid stocks for roses.—A writer in *American Gardening* considers Manetti stocks (popularly used) unsuited to American climatic conditions. Where perfect hardiness is required he has found *Rosa setigera, R. Wichuraiana* and *R. rubiginosa* superior; for, he says, "all make good, deep roots, and are little affected by dry weather when established, and are not at all disposed to sucker." The best of all stocks he considers to be a cross between Clothilde Soupert and Crimson Rambler, both varieties of *R. Multiflora.* These stocks are exceptionally vigorous, do not sprout, and are easily budded and in hardiness little inferior to the native species. The roots are easily splice-grafted, but the stems are not so satisfactory for grafting. For tree rose effects he prefers to bud high on strong sweet briar shoots and trim off all other shoots as soon as the bud has formed a fair top.

268. Grafted roses for forcing.—A. B. Scott has grown half a dozen varieties of forcing roses on their own roots and on manetti stocks. Since all but American Beauty and Perle des Jardins did much better as grafts, he concludes that grafted roses make strong, vigorous plants much quicker than roses on their own roots, produce as many, if not more flowers, of which a larger proportion are extra fine, and the plants are said to have more vitality. Manetti is considered best for stocks.

269. Citrus propagation.—Each principal citrus section and soil has its preference of stocks. In the heavy, moist fertile soil of Louisiana and Mississippi, *Citrus trifoliata,* a deciduous species, leads because of its vigor and hardiness, which are imparted to the cion because it becomes dormant in fall. In northeastern Florida trifoliata also leads, though some of the more lusty-growing stocks give good results in deep sandy lands. In central Florida, on sandy soil, rich in vegetable matter, pomelo stock does best, though the sour orange gives a hardier tree. In South Florida rough lemon is far in the lead. It is a rampant grower which does well on soils almost sterile for other stocks. The fruit it grows from cions worked on it is likely to be coarse. On heavy soils free from limestone, pomelo and sour orange do well,

though the trees are rather slower but produce better ripening, smoother fruit. Lime stocks make trees sensitive to cold and give too many failures.

Investigation has shown that for Florida, orange growers prefer rough lemon stock for "high pine" lands. Sour stock is considered better than sweet stock for all kinds of land. In Louisiana, sour stock is preferred by about 90 per cent of the planters. California growers who have tried sweet and sour stocks side by side on a large scale give data which warrant the conclusions: 1, that sour stock trees make more thrifty growth; 2, are freer from disease and are fully resistant to "foot rot"; 3, less liable to injury by cold while young; 4, the quality of the fruit is not impaired.

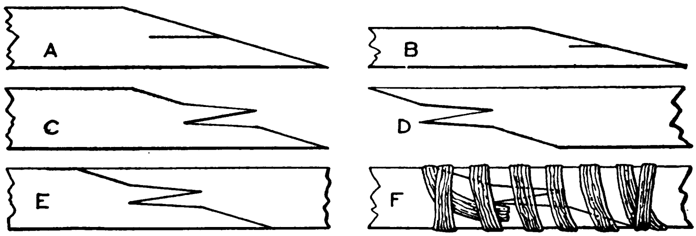

FIG. 172—ENGLISH "CLEFT" GRAFT

A, Improper angle for large cuttings, should not be parallel but slightly away from long side; B, ditto for small cuttings; C, D, proper angle for tongues; E, F, uniting and tying.

Orange on *Citrus trifoliata* stocks in California have made good growth in open culture. Satsuma and other varieties of the Mandarin class at five to nine years old were eight to ten feet high. This stock appears to resist drouth especially well, and the varieties of orange and other citrus fruits grafted on it appear to stand 10 degrees more cold than on other stocks and also to come earlier into bearing.

Seeds from only mature specimens should be saved for growing seedlings. It should be plump. Culls and drops allowed to rot are used, the seed being washed out and air dried after sifting in a strong stream of water. When the ground is warm enough the seed is sown in

southern Florida and the West Indies as early as December, but in northern Florida, Louisiana and California not till February or March. Cultivation is the same as for garden crops. By fall following the seedlings will be 6 to 12 inches tall and one-fourth inch thick. A tree digger may be used to lift them for transplanting in nursery rows, where they are kept free of soil crust and weeds.

270. Citrus stocks may be propagated by stem or root cuttings of fairly mature wood, but they are not as satisfactory for budding as are seedling trees because they grow slowly and are more irregular. Budding, grafting

FIG. 173—PACKING NURSERY STOCK FOR SHIPMENT

and inarching are all used more or less; the first is most popular. Dormant budding is usually done in late autumn or in spring after vigorous growth has begun, other budding may be done at almost any time during the growing season. Bud sticks are generally cut and stored a few days or even weeks before budding, because it is believed a larger percentage will grow. The process of budding is practically the same as for peach, except that the cross cut is made at the lower end of the longitudinal cut.

"Lopping" the tops of the stocks is done about three weeks after the budding to force the buds to develop shoots. The cuts, made about two inches above the

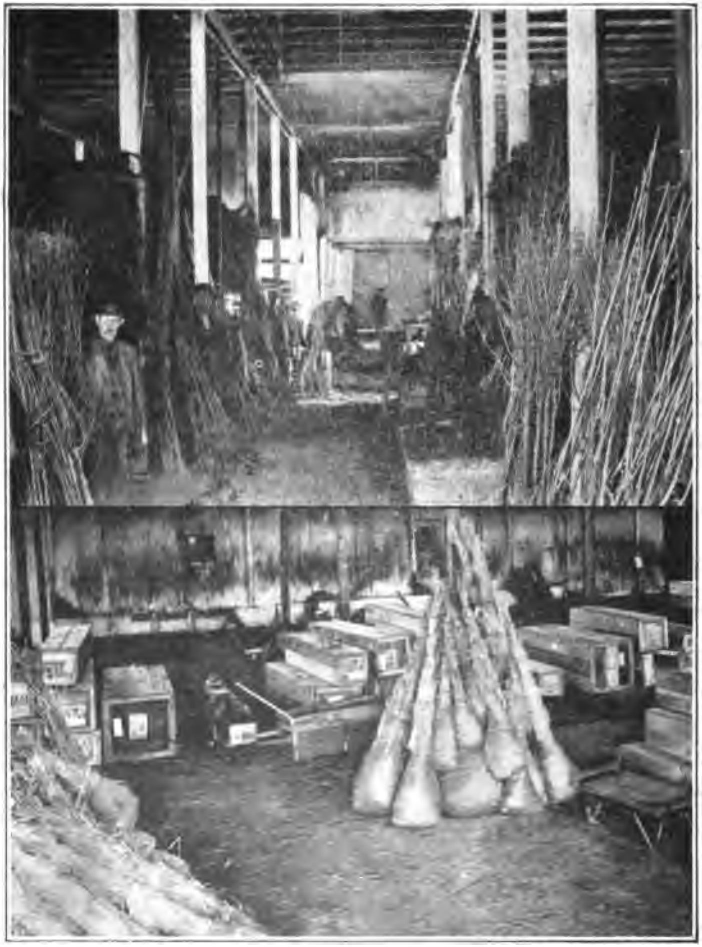

FIG. 174—NURSERY STORAGE HOUSE SCENES

Above, trees in the storage cellar bundled ready for baling and boxing; below, bales and boxes ready for shipment.

buds, do not completely sever the tops, which are bent over. One method is to bend the tops of one row toward, say the south end, and those of the next toward the north, so the cultivator may go up one inter-row space and down the next without serious interference. The tops remain attached till the sprouts are say 15 inches tall.

Another method, dependent somewhat upon placing the nursery rows in pairs about three feet apart, with wider inter-rows between the next pair, is to lop the tops of the pairs into the narrow middles and leave them there as a mulch until early fall, Some nurserymen favor this, because they believe a better growth of sprouts is thus

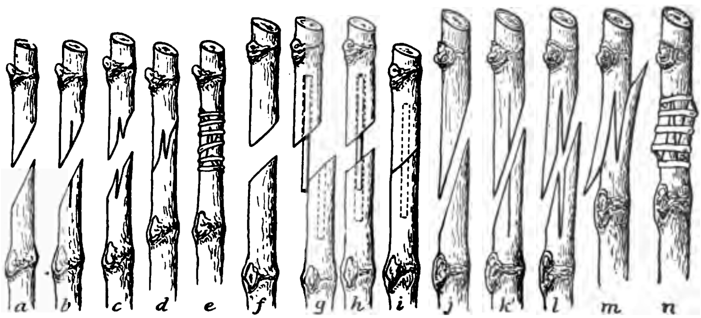

FIG. 175—THREE METHODS OF BENCH GRAFTING GRAPES

A to e, whipgraft; f to i, grafting with galvanized wire; j to n, Champin graft.

secured. The wider inter-rows are cultivated. In every case when tops are finally cut off, the stubs are cut off smoothly, close to the buds, to favor healing without scars. Staking the young trees is necessary, because the unions are at first weak.

271. Grape grafting is usually a necessity only (1) for working over undesirable varieties or seedlings to desired kinds and (2) for growing European varieties in regions where the phylloxera (280) exists. The former, scarcely a nursery practice, is made by cleft grafts below the soil surface, without tying or waxing, but with earth mounded

over the union and up to the upper bud. The latter is done in a variety of ways (Fig. 175). The reason for doing it is that American stocks, the ones always used, are less susceptible to phylloxera injury than are Eŭropean varieties. Care must be taken to prevent rooting of the cions, else no advantage will follow grafting. Attention is called to grape-grafting experiments in the paragraphs which follow.

Contrary to general belief, Daniel declares that the character of the cion graft and of the wine produced from the fruit is often changed, largely because of the difference in nutrition as a result of callusing the grafted parts and the consequent difficulty of sap circulation. By taking advantage of such changes, Daniel believes that it will be possible to produce new varieties by grafting so as to combine the good qualities of French fruit with the phylloxera resistance of American sorts. Grape growing by direct producers (those on their own roots) is considered most desirable, so they should be sought by grafting.

Degrully, a French scientist, has pointed out that variations in vines, due to grafting, should not cause apprehension. The thousands of acres reconstructed on American stocks still thrive and produce abundantly 20, 25 and 30 years after grafting. Variations due to grafting, he maintains, are as yet only of scientific interest.

272. Effects of vine grafting.—Because of agitation, the Society of Agriculture of France appointed a committee to investigate effects of grafting on yield and quality of grapes and wine. The committee concluded that where the factors of adaptation and affinity of stock and cion, as well as other necessary conditions for successful grape culture, have been realized, there appears to be nothing to warrant the claims that grafting has a deleterious effect on yield and quality of product.

273. Experiments in grape grafting.—In California, experiments in grape propagation warranted the following slightly condensed conclusions (Cal. Exp. Sta. Bul. 127): 1, A cutting graft of suitable variety makes as large and vigorous growth as a simple cutting, so by bench grafting no time is lost in establishing a resistant vineyard. 2, Resistant varieties difficult to root but easy to graft when old should not be bench grafted. 3, Care in callusing, planting and treatment in nursery and especially in keeping the grafts moist from the time they are made till they are in the callusing bed, (Fig. 105) will enable even an inexperienced grafter to obtain at least 60 per cent of good, grafted plants. 4, Callusing in sand insures more perfect unions and a larger percentage of successful grafts than planting directly in the nursery. 5, The moisture of the callusing bed should not be excessive. and the temperature should be relatively warm. 6, The growing grafts should be

watched closely in order to see that the roots of the cions are removed before they become large, and that the raffia is cut before it strangles the graft. 7. The English cleft graft (Fig. 172) is preferable to the Champin graft (Fig. 175), because it gives more perfect unions and can be made with more accuracy and rapidity. 8, Cions of two eyes are preferable to those of one eye, as they give more chances of success. 9, Rupestris St. George seems to be remarkably adapted to California soils (except the heaviest clays) and conditions, and is to be preferred to any variety yet tested wherever deep penetration of roots is possible and desirable. 10, All the eyes of the *Rupestris* stock should be cut deeply and carefully. 11, A vigorous and large-growing *Vinifera* cion promotes an equally vigorous growth of Rupestris St. George used as stock.

274. Bench grafting of grapes experimentally reported by Hedrick of the New York state station presents the following main features: The grafted grapes were more productive than those on their own roots; they were a few days earlier; the 19 varieties employed were all congenial to the three stocks used. Samples of the stocks used are shown at 1, Fig. 157. Two eye cuttings six to eight inches long were taken in the fall and buried in sand till needed in late March, when the work was done. Roots were cut back to an inch for convenience in handling by whip grafting (Fig. 157). Grafts on the previous season's wood gave many suckers; those on the original much fewer. After the operation the grafts were stored for callusing until planting time. All three of the stocks used—Clevener, St. George and Gloire—are recommended for trial commercially, and three others suggested as promising; viz., Riparia Grand Glabre, and two hybrids between *Vitis riparia* and *V. rupestris* known as 3,306 and 3,309. During the growing season, shoots from the stock (Fig. 157) and roots from the cion (Fig. 157) must be removed at least twice; the earlier the better.

FIG. 176—GRAFTED GRAPE VINE

Note shoot growing from stock below union at label.

275. Bench-grafting cuttings is unhesitatingly recommended by Biolitti of California for the following reasons: Both stock and cion are young and of the same size; unions are therefore strong and permanent. Grafting may be done under conditions favorable to rapid and effective work, in any weather, during three or four months, on rainy days when other work is not pressing or cannot

be done. One man who thoroughly understands all details can oversee several unskilled workmen, making it possible to employ cheap labor for much of the work. Cultural conditions are more easily controlled. There is less danger of inferior results due to excessively wet or dry weather during the growing season. In the nursery the vines can be cultivated, irrigated and generally attended to much more perfectly than in the field. Rigid selection of vines for planting can be made, rendering it possible to have nothing in the vineyard but strong plants and perfect unions. As perfect stands can be obtained in vineyards the first year in any soil or season as when planting ordinary non-resistant vines. Unions of vines can be placed exactly where wanted. Land where the vineyard is to be planted can be used for other crops one year longer than when field grafting is adopted. All cultural operations during the first year are much less expensive than in vineyard grafting, as they are spread over a much smaller area. Two acres of nursery will produce enough bench grafts to plant 100 acres of vineyard.

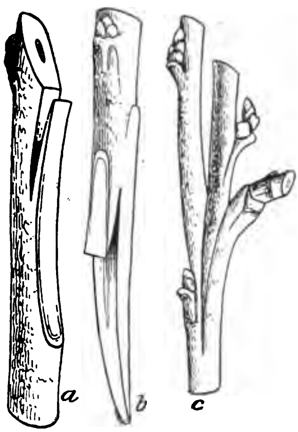

FIG. 177—GRAFTING CONIFERS

a, stock, b, cion in English "cleft" graft. b, English method for cypress, juniper, etc.

In short, starting a resistant vineyard by means of bench grafts is much better than by any other method used at present, because it is least costly and gives best results. This is true whether the bench grafts are produced at home or bought at present market rates. Growers are earnestly cautioned, however, against planting any but first choice bench grafts; second and third choice are little better than field grafts.

All that can be said in favor of nursery grafting and bench grafting roots, is that vines so produced are fairly good when bench grafting is impracticable. These methods permit root grafting with stocks which, owing to rooting difficulty, are very difficult to bench graft as cuttings. By their means resistant cuttings too small to bench graft may be utilized, and a larger percentage of well-grown grafted vines obtained from the nursery.

On the other hand, as the stock is at least two years old when grafted, there is reason to fear that with some stocks many unions will fail as the vines become older. The vines are larger when taken from the nursery, thus increasing cost of removal. There is little if any gain from growth over bench grafts when vineyard planted. Finally, the method requires a year longer, and is more expensive.

276. Grafting resistant grape stocks.—F. Gillet obtained best

results with riparia stocks. One and two-year rooted cuttings were used in preference to plain cuttings, because of a gain of one year and because a larger per cent will grow. In field practice he used rooted cuttings just grafted and rooted resistant stock in alternate rows. While he secured 85 to 90 per cent of the former, only 60 per cent of the latter grew, and these produced very few grapes the year set out; the former gave eight to eleven pounds a plant. Mr. Gillett considers bench grafting resistant vines the best, cheapest and quickest way to reconstruct a vineyard or start a new one.

277. Influence of grape stock on crop.—L. Ravaz, a French investigator, reports 28 years' consecutive yields of two varieties of European grapes grafted on various American stocks. Though much decadence is noted in the vines grafted on certain stocks, the decline in yield and vigor is attributed to such causes as variation in resistance to phylloxera (280), unseasonable weather, lack of adaptation to soil, etc., rather than to influence of grafting and old age. The general deduction is that under proper conditions grafted vines do not deteriorate with age more than do ungrafted ones.

278. Grafting green grape vines.—In Rumania the tongue graft has been successful with green wood not less than one-fourth inch diameter at the point grafted, and the wood of both stock and cion hard enough to be with difficulty compressed between thumb and finger. The usual precautions of mature wood grafting must be observed. After union the grafts may be handled like cuttings, or roots may be started by layering on the stocks below the grafts. The advantages claimed are: The method simplifies the operations by obviating stratification of both stocks and cions; 2, it is cheaper and a larger percentage of grafts succeed; 3, the chance element is reduced to a minimum; 4, it seems to promise greater success with varieties difficult to unite when mature.

279. Seedling vines as cions.—Trabut suggests that new varieties of grapes may be quickly brought into fruit by grafting the seedlings on green shoots of established vines. He has secured successful results by the following method: In early June the seedlings which had only their cotyledons, were cut as for ordinary cleft grafting and inserted in the tips of green shoots whose ends were wrapped with small paraffined bands secured with raffia. The completed grafts were then covered with paraffined paper bags to preserve humidity. In about two weeks the parts united and the cions grew vigorously. By October the unions were almost invisible and the canes often 10 feet long.

280. Phylloxera, a plant louse which in its nymph stage feeds on roots of grapes, and forms galls on the leaves, the latter being the most conspicuous sign of infestation. The insect does little appreciable damage to American species of grapes, hence these are used as stocks for European varieties, which are so seriously attacked that, except in California where the insect was unknown until

recently, all attempts to grow European grapes in America during more than 200 years resulted in failure. When American vines were taken to Europe, the insect practically ruined the grape industry, as it has since threatened to do in California. American grape stocks seem to be the only salvation.

281. Root-grafted vs. budded trees.—For many years fruit growers and nurserymen have discussed the relative advantages and disadvantages of whole root, vs. piece root vs. budded trees, largely without experimental evidence. Arguments have mostly been generalized statements, only too often warped by individual prejudice or pocketbook. Before summarizing the experiments recently published, some leading opinions should be cited and methods outlined so the reader may choose what appeals to him. The following points must be borne in mind.

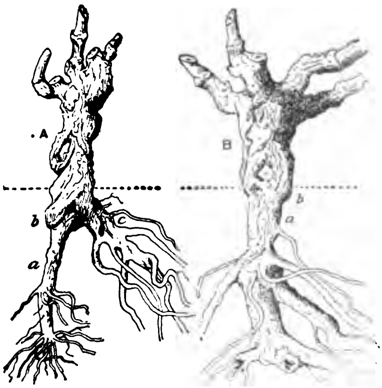

FIG. 178—GRAFTED GRAPES

A, effect on resistant stock of allowing cion to take root; a, resistant stock small because cion has rooted at c; B, vine in which cion has not been allowed to root. Note smooth union at b in each case.

Nursery budding upon spring-set stocks is done during summer, but no growth occurs till the following season (341). The stocks before being planted in the nursery are trimmed for obvious reasons. In whole-root grafting the cions are crown set and roots similarly trimmed. In piece-root grafting several bits of root are used, the top piece with a crown, the other pieces without any. These latter are, of course, smaller. Thus piece-root grafting creates a problem of its own because of the varying sizes and vigor of the pieces. Piece-root grafting may therefore be said to be unfairly pitted against both budding and whole-root grafting, which under equal conditions are equally valuable methods of propagation.

Differences of growth characteristic of each method result from differences of stock trimming, not methods of propagation. Even casual observation will show differences in root development between budded and root-grafted trees, the latter being more horizontal, prolonged and shallower on one side of the tree than the

former, when dug from the nursery row—all this apart from differences characteristic of variety. Such differences are due to differences in stock cutting. Doubtless if stocks were cut alike for both budding and root grafting development would be closely similar; for when short pieces of root with few lateral branches are used they must grow differently from long roots with numerous branches. In strong stocks where only the tips are cut off and budding performed root development is largely if not wholly lateral, whereas when small pieces are used growth is mainly downward. Hence the theoretical conclusion that at a given nursery age, whole-rooted trees have naturally and necessarily longer and stronger roots than those grown from piece roots.

When root pieces are very small the resulting trees will be small at the end of the first growing season. Hence nurserymen often cut back the tops so as to secure stout, straight bodies which show no trace of the growth ring between seasons, and which do not branch too low or send up a crooked leader from a lateral bud, due to the winterkilling of the terminal one. If the trees are sold as two years old there can be no objection to this practice, but if the age is reckoned from the cut, an injustice is almost surely done the fruit grower, because greater quantities of roots are removed at digging time than would be the case with true one-year trees. The first season's growth should always be high enough to form a good tree body of the right height, whether or not the fruit grower is a believer in low or high-headed trees.

Budded trees of the same age as root-grafted ones grown in the same field usually average larger, the difference diminishing in proportion as the length of the root stock piece increases. Similarly their root systems go deeper and show more symmetry, but these characteristics also lessen as the root stocks lengthen.

It must not be concluded from the discussion so far presented that budded trees are necessarily superior to root-grafted ones, though it is probably a fact that large numbers of trees produced

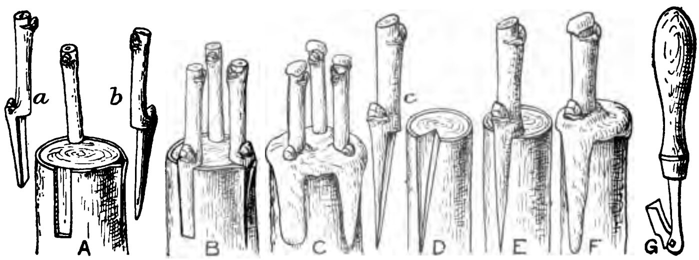

FIG. 179—TWO STYLES OF CROWN GRAFTING

A, slot of bark removed for cions a, b; B, cions fitted in place; C, completed graft; D, slot of wood and bark removed; c, cion cut to triangular wedge to fit slot in stock; E, stock and cion fitted; F, completed graft; G, slot making or "inlaying" tool.

from small, short and weak stock pieces are decidedly indifferent and even distinctly poor. The point is that the two methods form trees whose roots at least are different in appearance and development. Opinion seems to be general among fruit growers and nurserymen that budded trees root more deeply than do root-grafted ones and make longer-lived trees when transplanted to the orchard. It is therefore concluded that more depends upon the handling of stocks at the time of performing the operations than upon the method *per se*. In the northwestern states where trees on their own roots are preferred, piece-root grafting is not only more economical of stocks, but has the merit that the cions soon take root in the orchard, and the trees become "own-rooted" (242). In other sections budded stock is perhaps better than root-grafted trees of the same age and grown under the same conditions; at least as dug in the nursery. Nevertheless as good trees can be grown by the grafting method. As to results in the orchard the following paragraphs will be interesting.

FIG. 180—TRENCHER AND ROW MARKER

Used to mark rows for nursery stock planting.

282. Whole vs. piece root vs. buds in apple propagation.—During the past decade or two work has been done at experiment stations in Pennsylvania, Oregon, Kansas and Alabama, to determine the relative value of whole and piece roots and budding. After 10 or more years reports show that differences must be measured by decimal fractions to be discovered at all. In Pennsylvania after a decade of work, according to J. P. Stewart, trees propagated on top-piece roots are slightly in the lead in all respects, with those on whole roots second. In Alabama, trees on bottom pieces of stock roots show a slight superiority at the close of the second season, with those on top pieces second, and whole roots third. In Oregon, trees on whole roots were slightly ahead at the close of the fourth season, in the single variety remaining at that time, with those on top-pieces again second.

In Kansas 64 trees grafted on whole roots averaged one-tenth inch larger in trunk diameter, at the end of 10 years' orchard growth, than 30 trees budded in the usual manner on whole roots. They in turn averaged one-fifth inch larger than 102 trees, involv-

ing some additional varieties propagated on piece roots. No differences in growth or vigor were observable in the orchard. In another Kansas experiment three varieties of 400 trees each, on whole roots, were compared by Judge Wellhouse with 400 of the same varieties on two-inch piece roots. In the latter case, the young trees had developed considerable numbers of roots directly from the cions, thus making the trees largely own rooted, while no cion roots were developed on whole-rooted trees. After 19 years in the orchard, the only difference observed was in the greater number of sprouts from the whole-rooted trees.

From all these data it is obvious that none of the present forms of propagation has any material advantage over any other. It may be of distinct advantage to get rid of the seedling root altogether, either by using the shortest roots practicable and then cutting them off during transplanting after roots have developed above, or possibly by a direct rooting of the cions.

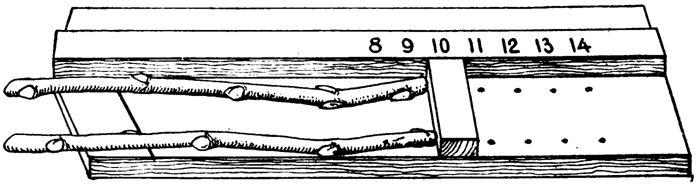

FIG. 181—GAUGE FOR CUTTING GRAPE STOCKS

This insures accuracy as to length. The base of the cion is placed against the adjustable crosspiece and the cutting moved back and forth till a bud comes just to the right of the guide line when it is cut off flush with the edge of the board. Thus 1½-inch internode is secured above the top with only 1½ inches maximum variation in total length.

Elimination of seedling roots would at least obviate the numerous ill effects of poor unions. It would also reduce the opportunity for crown-gall infections, eliminate the possibility of harmful influence of variable seedling stocks upon cions, and make it possible to develop definite and standard root-systems, with which injuries from root aphis and kindred difficulties might well be greatly reduced or entirely eliminated. This important array of advantages, all of them practical, is by no means impossible of attainment.

283. Selection of cions is of prime importance in grafting. None but thoroughly mature wood, cut while the buds are fully dormant, should ever be used. Preferably it should be one year old, though sometimes two-year and even three-year wood gives good results. Pithy and soft wood is worthless for grafting. Cions may be packed in damp moss or sand and stored in a cool cellar until buds

on trees exposed to the weather begin to break. If the moss is too wet the cions will become water soaked and worthless. When cutting cions from cion sticks the lowest few inches should be discarded, because the buds are inferior and may not start at all. The tips are often immature and should also be discarded.

284. Shipping cions long distances.—The following method of shipping mango cions from Ceylon, India, to Washington, D. C., recommends itself to shippers of other cions. The cut ends of the cions were covered with collodion, the bud sticks dipped in clay mud, packed with a small amount of moist coir (refuse cocoanut fiber) and forwarded in cylindrical tin tubes.

CHAPTER XV

GRAFTING WAXES, WOUND DRESSINGS, ETC.

285. Grafting wax.—The great majority of the many recipes for grafting wax vary only in the proportions of the three ingredients, resin, beeswax and hard cake beef tallow or linseed oil, sometimes used instead of tallow. These variations are largely due to personal preference, though in some cases the consistency of the finished wax is thus purposely varied. For soft waxes the proportion

FIG. 182—NURSERY TREE PESTS
1. Hairy root and crown gall. 2. Woolly aphis.

of tallow should be increased; for tough ones, that of beeswax. Thus any formula may be varied to secure wax for any kind or character of use indoors or out.

As a rule, liquid waxes are less popular in America than in Europe, where also pitch waxes and grafting clay (fresh cow manure free from straw, three parts; clay or clay loam, seven parts and cow hair half a part) are more in use than here. In the table which follows the first formula is probably the most popular. The functions of grafting wax are to protect the injured tissues from decay and

weathering and to prevent losses of plant juices by evaporation. Hence soft wax is better than hard, because it may be fitted more closely to the wood and into chinks. Large wounds should first be trimmed of ragged edges, then swabbed or sprayed with bordeaux mixture and finally covered with wax.

The resin and beeswax waxes are all started alike; the materials previously made into small lumps may all be placed in the pot together, but preferably the resin is melted over a very gentle fire first and the other ingredients added. Boiling must be avoided. After stirring to make uniform, the melted mixture is poured into a tub of cold water and flattened out so it will cool evenly. When cool enough to handle, it is kneaded and pulled till the color resembles molasses taffy. To prevent its sticking to the skin, the hands are kept greasy. Should lumps

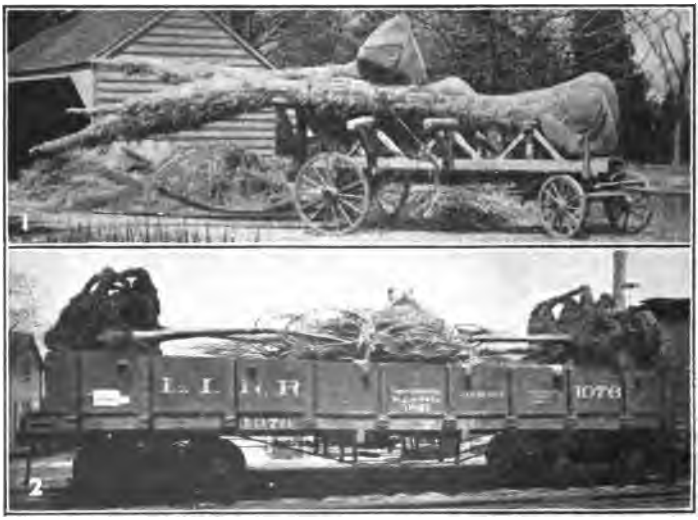

FIG. 183—LARGE TREES BALED FOR SHIPMENT

1, wagons are used for short hauls. 2, twenty-five maple trees make up this carload.

occur (because of improper handling), it may be re-melted and re-worked. Usually the wax is made into balls or sticks for convenient use. It will keep indefinitely. Linseed oil for making grafting waxes must be free from adulterations such as cottonseed oil.

Alcoholic waxes are considered too soft to stand the heat of American summers. They melt and run. For winter work for covering wounds and for bridge grafting, their softness is an advantage. To make them the resin is melted slowly, tallow added and the kettle removed from the fire. When cooled somewhat, alcohol (and turpentine when in the recipe) is added. Stirring continues from the adding of tallow till the mixture is nearly cold.

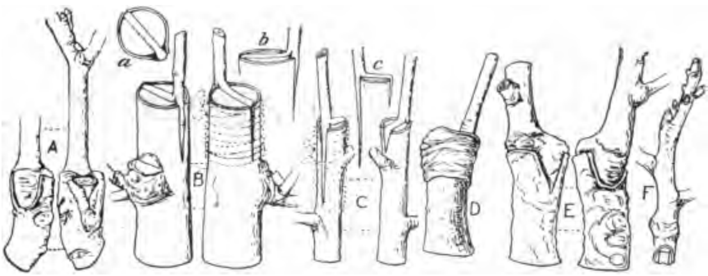

FIG. 184—SMITH'S IMPROVED METHOD OF GRAFTING

A, old and defective "rind" grafting; B, large branches with graft in position, a, b, other views of graft; C, small branches grafted ready for waxing; D, completed graft; E, large graft one year old; F, small graft one year old.

286. Waxed string used in root grafting is made by placing balls of No. 18 or 20 knitting cotton in hot resin wax, turning them for a few minutes, removing and letting them drain and cool. Before immersing, the outside end of each ball should be definitely located where it can readily be found, else unwinding will be difficult. This string is used mainly for tying root grafts. It is strong enough to make a tight wind, yet weak enough to break without hurting the hands. It does not need to be tied, since it readily sticks.

287. Waxed bandages may be prepared in the same way as waxed string. They are best made of old cotton sheets or similar cloth torn in strips of any desired width and wound in rolls like tape. For binding large wounds, as in bridge grafting, they are excellent.

POPULAR GRAFTING WAXES

	Resin	Beeswax	Tallow	Linseed Oil	Alcohol	Turpentine	Remarks
	Pounds	Pounds	Pounds	Pint	Ounce	Table-spoons	
1	3	3	2	-	-	-	J. J. Thomas's wax
2	4	2	1	-	-	-	Cheaper than No. 1.
3	4	2	-	1	-	-	Increase oil for softness.
4	6	2	-	1	-	-	Increase oil for softness.
5	1	1 ounce	-	-	5	1	Melt resin, add tallow, remove from fire and stir in liquids gradually. Can or bottle. Apply with brush.
6	4	1	1	-	-	-	Somewhat harder than No. 2
7	6	1	-	1	-	-	Brush on thickly while hot.
8	6	1	1	-	-	-	Use warm indoors.
9	4	1	-	1½	-	-	Raw oil. A hard, warm-weather wax.
10	4 to 5	1½ to 2	-	1 to 1½	-	-	An outdoor wax.

289. Rubber strip in grafting.—R. B. Rogers, an English experimenter, has found pure rubber electric wire insulation strip useful in grafting. It is bought as rolls. The grafts are fitted as usual, the strip stretched well and wound tightly so as to cover the exposed part, exclude air and hold the cion firmly in place. A strip four or five inches long and one-half inch wide is enough for ordinary grafts. Rubber solution should be used to make the ends stick. Strip need not be removed, since it stretches and rots with graft growth. Old strip quickly spoils in the sun.

290. Wrapping grafts with cloth, rubber, waxed paper, plain thread, waxed thread and plain thread with the unions waxed, were experimentally tried by the government to determine the effect on crown gall. From the large amount of data it is concluded that

wrapping reduces injury, the best material being rubber, then cloth (which gave the largest percentage of smooth healthy trees). Cloth is also cheaper. The investigators strongly oppose wrapping with thread and then waxing.

291. Bass, the inner bark of basswood, has until recently been used in greenhouses and nurseries to tie plants, buds and grafts. Raffia has almost replaced it.

292. Raffia, the lower epidermis of a Madagascar palm (*Raffia ruffia*), peeled in narrow strips and dried, is extensively used in America and Europe for tying vines, flowers, celery and in graftage. It is soft, strong enough for the purposes, and not quickly altered by moisture or temperature. Because of its cheapness it has displaced bass in nursery and greenhouse practice. Its chief fault is its tendency to roll when dry. Moistening overcomes this. As received from abroad, it is in plaits or skeins. Fig. 185 shows one of these unraveled.

FIG. 185—SKEIN OF RAFFIA

293. Grafts in moss and charcoal.—R. C. de Briailles has simplified grape bench grafting by the following plan:

As the grafts are made they are placed in a box containing a three-inch layer of damp moss and charcoal (three to one) and covered with another layer about half as deep. So on till the box is nearly full, the remaining space being filled with packing. The box may thus be shipped or the grafts treated at once by being placed in a room warmed to 50 or 60 degrees. Within 24 hours the buds start to swell, and in a week may be one-half inch long, when the moss is removed for inspection. If all is well, new packing is applied about half as thick.

If any grafts are rotting, the whole are exposed for 24 hours and then covered. If too dry, a thicker layer of packing is added and the box stood in water of the room temperature till the packing is moistened nearly up to the callus. The tops of the grafts must not be wetted, else rotting may follow. Watering thus once a week will be enough.

In two or three weeks the grafts will have callused and leaf

growth will have started. The plants may then be hardened off and transplanted in the field.

Advantages of this method are that grafting is simplified, since no tying is needed, the grafts are placed in the box as made without unnecessary handling, a development of vegetation is secured in three weeks equal to that of two months by ordinary outdoor practice, a more perfect union and callus are secured and disbudding of the stock is unnecessary.

294. Dressings for tree wounds.—Fruit growers have long used paints, tars, waxes and other substances as coverings for wounds on trees. The New York state station reports results of experiments with white lead, white zinc, yellow ocher, coal tar, shellac and avenarius carbolineum. The summary of Bulletin 396 by Howe is slightly condensed in this and the next paragraph. In all cases undressed pruning wounds have healed more rapidly than those whose surfaces have been protected. The first season shellac seemed to exert a stimulating influence on wounds, but the second season this disappeared. Of all materials used shellac was least injurious, but it adheres to wounded surfaces poorest of all. Carbolineum and ocher caused so much injury that neither should be used. Coal tar not only caused injury, but quickly disappeared, either through evaporation or absorption. White lead and zinc caused some injury when applied, but the wounded tissues recovered rather quickly, and at the end of the first year the injury was not very marked; at the close of the second season it had nearly disappeared. These two are the best protective substances used, and of the two white lead is the better. Nothing is to be gained in treating wounds by waiting before applying the dressings.

The treatment of peach tree wounds with any of the substances caused so much injury that it may be said peach wounds should never be treated with any of them. This may be inferred for other stone fruit trees. There is nothing to show in the experiment that it is worth while to treat wounds large or small with any of the substances in common use. Had there been a longer period of observation, it might have been found that wood exposed in the larger wounds would have been somewhat saved from decay which often sets in on exposed wood of fruit trees. It may prove to be worth while, therefore, to cover large wounds, in which case white lead is undoubtedly the best dressing to use.

CHAPTER XVI

METHODS OF GRAFTING

295. Classification of graftage.—Graftage methods naturally fall into three general classes: 1, Inarching, or grafting by approach, in which the cion is not severed from the parent plant until after union is complete; 2, cion grafting, or true grafting, in which a twig with at least one bud is placed upon or in a stock; and 3, bud grafting, or, to use its popular term, budding, in which only one bud is placed beneath the bark of the stock upon the surface of the young wood.

296. Inarching, or grafting by approach (Fig. 186), which is often placed in a class by itself, may for convenience be treated here. The only point that distinguishes it from other styles in this grouping is that the cion is not separated from the parent plant until after union is complete. In other words, inarching consists in making one plant unite with another while still growing on its own roots.

FIG. 186—INARCHING

A, stock; B, cion; C, stock and cion bound together; D, cuts on stock and cion to hasten union.

A small slice of stem of both stock and cion (Fig. 186, D), is cut with a sharp knife, and the cut surfaces brought together and tied firmly

until they have united. In outdoor practice waxing and staking are usually necessary to prevent drying and working loose. After union is complete the base of the cion and the top of the stock are cut away.

While this is undoubtedly the original or natural method of grafting (since all grafts in the forest are formed in this way either between two trees or two limbs of the same tree), it has comparatively limited application in business horticulture, because other methods are less cumbersome and more economical of time and space. It is used, however, in Europe and elsewhere in the making of cordons, espaliers, etc. In orchards where Y-crotches have been allowed to form it is also useful in establishing living braces between the arms of the Y. For ornamental purposes it has been used in the Boboli gardens at Florence, Italy, where an avenue 100 yards long has been arched over by European oaks

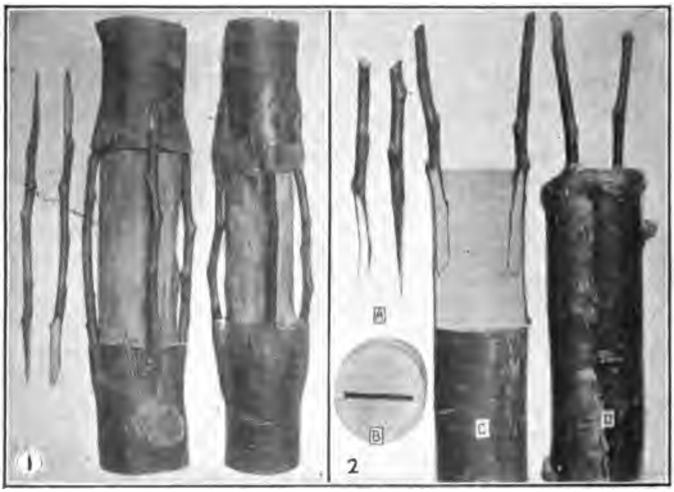

FIG. 187—POPULAR GRAFTING METHODS

1, Bridge or repair graft, cions at left; 2, cleft graft, A, cions, B, cross section showing insertion of cions at opposite ends of cleft in stock; c, transverse section showing vertical position of cions; d, finished graft.

whose tops have been united by modified inarching, the difference being that neither cion below the union nor stock above have been cut, but both allowed to grow.

In the topics, inarching is used for propagating the mango. Seedlings are grown in five or six-inch flower pots and placed on stands beneath trees to furnish cions and within easy reach of branches to be united, as already described. After union the potted trees are grown for a time in the nursery before being set in the orchard. Various citrus fruits and camelias were formerly inarched, but are now mostly veneer grafted.

Inarching on young seedlings, according to Oliver, has proved superior in simplicity, rapidity and results to inarching on plants in five and six-inch pots. It has a wider range of adaptability than budding and requires less skill. The seedling may be used either as stock or cion. Nurse plant propagation is a special form of seedling inarch in which the plants develop a strong aerial root from the base of the cion in about 18 months after the union of certain tropical fruits (mangosteen on related species of *Garcinia*) was considered complete and the stock top and seedling root had been severed. This root pierces the ground, after which both top and roots develop rapidly. The method has not been fully tested, but has been announced for other experimenters to test.

297. Inarching.—Daniel concludes from many series of experiments with unrelated plants (kidney bean and cocklebur, kidney bean and castor bean, sunflower and melon, cabbage and tomato, chrysanthemum and tomato, Jerusalem artichoke and black nightshade, coleus and acaranthus, cineraria and tomato, aster and phlox, coleus and tomato, maple and lilac, zinnia and tomato) that "the old idea that only plants belonging to the same family can be grafted on each other does not apply to grafting by approach."

The most perfect grafts in these experiments were made between plants nearest alike in vigor and vegetation. The nature of the tissue of the different plants also played an important role. Tomato and cabbage and artichoke and nightshade gave good unions on account of their herbaceous nature and rapid growth, while aster and phlox, somewhat advanced in growth, and year-old maple and lilac united with difficulty except on very young shoots.

298. Grafting classified as to position.—So far as position is concerned, grafting may be classified as: 1, root grafting, in which only a root is used as a stock; 2, crown grafting, in which cions are inserted in stocks at the collar; 3, trunk or stem grafting, in which they are set in the tree below the branches; and 4, top grafting, in

which the work is done among the limbs. Methods of inserting the cions may vary in all these classes.

299. Cion graftage is of three general kinds: bridge or repair grafting, root grafting and top grafting.

300. Bridge or repair grafting sometimes erroneously called inarching, is not properly a propagation process, but it may well be discussed here, because it may be the means of saving valuable trees which have been injured by mice, rabbits, hogs, human carelessness or accident.

Unless the girdle has cut through the sap wood it is an error to say that bridge grafting is necessary to establish connection between root and top; for the upward current of sap passes through the sap wood and not through the bark. It is correct, however, to say that the bridge establishes a connection between top and root, for the downward flow of elaborated sap is through the bark layers. As soon as the wound is discovered the operation should be performed. If the injury occurs in winter the wound should be protected to prevent drying. In spring when the buds begin to swell the grafting should be done. The operation is performed as follows (Fig. 187):

The injured, and perhaps dry bark, on both upper and lower edges of the wound is pared back to living tissue. Several cions are cut long enough to extend a little beyond these trimmed edges, and inserted beneath the bark both above and below, thus making little "bridges" across the gap. The ends of the cion are cut obliquely, to insure fitting of the cambium layers of cions and trunk. It is often a help to bow the cions outward slightly, because the spring thus formed aids in holding them in place. But these and other minor details may be left to individual preference. If placed an inch or so apart around the trunk, enough cions should succeed to save the tree. Both wound and cions should be completely covered with grafting wax, preferably made warm so as to fit into every chink and thus exclude air and water. In a few years the cions will grow together and in time lose their identity in a smooth trunk.

Bridge grafting is a makeshift method not to be compared with proper protection of trunks by keeping animals out of the orchard, by avoiding accumulation of grass, straw, etc., in which mice might form nests, and by using trunk protectors—splints, tarred or building paper, but preferably one-half-inch galvanized hardware cloth—around the trunks until the trees have developed rough bark (Fig. 146). Such methods will prevent the necessity of bridge grafting except in cases of unusual accident.

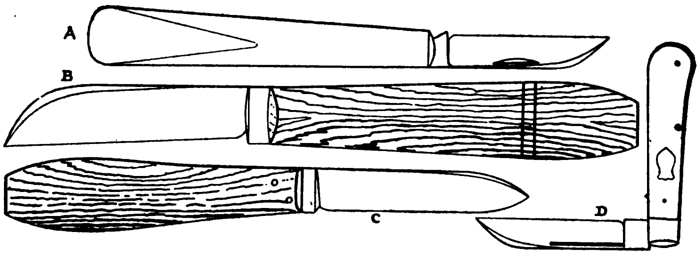

FIG. 188—VARIOUS STYLES OF GRAFTING KNIVES

A, closing blade propagating knife with bone bark lifter; B, C, nursery grafting knives, blades stationary; D, pocket grafting knife.

When the girdles are narrow—say only one to three inches—no bridging may be necessary. In such cases, however, it is well to err on the safe side by covering the wound with grafting clay (half clay and fresh cow manure) and bandaging this in with cotton cloth, or by using grafting wax as described above. Often such wounds will heal over in a single season.

301. Root grafting, perhaps the most generally practiced nursery method, is usually performed by means of the whip or tongue graft, a method employed only with small stocks generally one or two years old. It is oftenest done during winter in a cool, humid room. Should the air be too dry or too warm, the grafting wood may be injured by drying. Never should the work be done near a stove or a radiator for this reason. When necessary

to use a warm room, stocks, cions and finished grafts should be kept covered with damp rags or burlap.

302. Grafting knives (Fig. 188) may be of any thin-bladed, sharp-edged style; at least for whip graft work. For herbaceous and other delicate grafting a budding knife will answer. It is too light for most other methods. The knives popular in nursery practice have fixed wooden blades and cost about $2.50 a dozen.

FIG. 189—TONGUE GRAFTING
How to hold knife.

303. Whole-root grafts. — When roots of seedling trees are used for grafting, just as they come from the soil, except perhaps for trimming and slight shortening, the resulting trees are said to be "whole-root grafts." To make such trees the graft is placed at the crown, so the term "root graft" is erroneously used, the proper term being "crown graft." The roots are by no means "whole"; first, because a good deal has unavoidably been left in the ground when the seedling was dug, and second, because the roots must be shortened so the finished graft will not exceed nine inches and thus be too long for best handling in the nursery. The seedling roots are either single tap-roots four to six inches long, or shorter where several branches occur near the crown. Usually the lateral roots are cut off close to the main root, otherwise the grafts are difficult to make and to handle both in bundling and in planting.

304. Piece-root grafts are made from cions six or seven inches long and bits of root only three or two inches long. First grade, or number one, apple seedlings often make three and sometimes four pieces, though the average would probably be not more than 250 piece stocks to the 100 roots as bought. Number two seedlings will rarely reach 150 pieces to the 100 roots. When stock is costly or

scarce nurserymen sometimes lengthen the cion and shorten the roots even to 1½ inches. One of the so-called advantages thus gained is that the cions develop roots after the grafts have been planted. The chief effect, then, of the root piece is to act as a nurse until the cion is able through its own roots to care for itself.

Short pieces have been specially popular in the prairie states where, because of severe winters, roots as well as tops must be hardy. The practice there has been common to make cions 8 to 12 inches long, to use a very short root piece and to plant as deep as the top bud. By

FIG. 190—STUDENTS PLANTING ROOT GRAFTS

Ten thousand to thirty thousand made annually at Pennsylvania State College.

the time the tree is dug the nurse root will have fallen off or may be cut away. Thus trees are secured on their own roots and are considered superior to those in which the seedling roots are of unknown hardiness. Some varieties of apples readily take root from cuttings, but root grafting is favored, because there is less trouble from having to operate several methods often at busy times of the year.

305. Making root grafts.—The whip or tongue method

is almost universally employed in the making of root grafts. A long oblique cut (Fig. 189) is made at the base of the cion. Then a sloping and very slightly curved cut is made half way between the lower end of this first cut and the center of the twig. Its direction is upward in the wood but not exactly with the grain. The knife blade is forced in not less than one nor more than one and one-half inches. Generally both cuts are made before the cion is cut from the cion stick. By this means the length of cions may be accurately gauged.

Roots or stocks are cut in the same way, about three inches long, except as noted. The top piece is cut at or perhaps one-half inch above the crown or collar.

Stocks and cions are then accurately and snugly fitted together so the tongues interlock and with the cambiums in contact. It is well that the diameters of stock and cion be approximately equal, though large stocks and small cions if properly fitted will give good results. Since it is usually impossible to have both sides of cion and stock come even, the cambiums on only one side need touch each other. When sloping and tongue cuts are made properly, stock and cion will fit together without overlapping ends of bark, which might not grow together and might thus present a point of infection for decay or disease. Crown gall (Fig. 182) or root knot, the chief enemy, seems unable to get a start except through a wound of some kind. Overlapping tongues mean imperfect unions and unhealed wounds for one or more years.

After adjustment, stock and cion are bound together with knitting cotton, either waxed or not. Four or five turns around each end of the fitted parts are enough. To avoid tying, some operators pass the first turn or two over the end of the string and draw the other end through the notch between stock and cion and snap off with a sudden jerk rather than a steady pull. Those who use waxed thread merely cross the last turn or two over the previous turns and break without tying or passing through the notch. The least possible quantity of thread

of, say, No. 18 or 20 size should be used—just enough to keep the parts in place until the grafts are planted. In order that the thread may decay quickly, it should not be waxed. Indeed, some propagators contend that binding is a disadvantage because they claim that as the callus forms and the stem expands the cord cuts the soft tissues and thus favors the entrance of crown gall and hairy root (Fig. 182). Therefore, they leave the grafts unwrapped, but use extra care in fitting the parts together.

306. Graft wrapping machines are coming into use in some of the larger nurseries because they economize time and cost and do work said to be superior to hand wrapping. In a circular describing the "Reed-Bell" machine the following passage (condensed) occurs:

FIG. 191—WHIP GRAFTS WITH TOO MUCH CALLUS

An account carefully kept during several weeks of a grafting season shows the machine-wrapped grafts cost, on an average, five cents a thousand for twine, 11 cents for wrapping, a total of 16 cents a thousand; a saving of 34 cents a thousand over calico wrapping. But what is of more importance, the tension of the thread may be adjusted to wrap the graft so tightly that it may be taken by the root, thrown or shaken without risk of loosening.

In many tests, either root or cion has broken, rather than loosen or break at the splice. Hence in planting, grafts may be handled almost like cuttings without fear of breakage, resulting in the saving of thousands of trees.

307. Root graft storage is the same as storage of cuttings (176, 177), the grafts being tied in bundles of 100, each bundle being correctly labeled with the name of the variety before being placed in damp, green sawdust, sphagnum or sand in a cold but frost-proof room or cellar until spring. Unless the temperature is below 40 degrees, and unless well ventilated, there is danger that the grafts may heat, rot or sprout and thus be ruined. During the several weeks until planting time the wounds callus (Fig. 191) and the parts grow together so that when planted spongy tissue covers the points of contact.

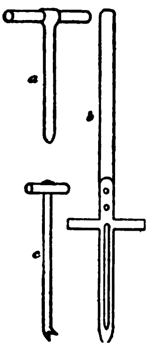

FIG. 192—NURSERY DIBBLES

Planting of root grafts in nurseries is done as soon as the ground can be worked in spring, the soil being fitted by deep plowing (preferably the fall before) and by several harrowings before being marked out. Three methods of setting are in vogue—dibbling, furrowing and planting with machines. In each case the grafts are set so the top bud of the cion is just above the surface.

Dibbling (Fig. 23) is done only in small nurseries or where only a few grafts are to be planted. Besides its slowness it is objectionable because of the risk of leaving air spaces around the lower ends of the grafts, thus effectively preventing growth. In its practice, holes about eight inches deep are made in the ground eight or nine inches apart with iron bars or pieces of rounded 2x4 scantling six feet long, sharpened to long points at their lower ends. In these holes the grafts are placed and earth pressed against them full length with large dibbles (Fig. 192).

In the furrow method (Fig. 180) a furrow eight inches deep is made with a turning plow, the grafts placed against the vertical side, and soil plowed back against them. The work is finished either by men tramping the earth against the grafts individually or by machine (Fig. 193) with two wheels set obliquely so as to press the soil downward and against the grafts when drawn by horses down the rows. Planting machines (Fig. 100) are similar to those used for transplanting cabbage, strawberry, sweet potato and other truck crops. During the growing season the nursery rows are cultivated by weekly shallow stirrings of the surface soil with cultivators and by hoeing out weeds among the growing grafts. At the end of the first season's growth, fruit trees should be three to five feet or even taller in some cases. Trees of such heights are ready for orchard planting. Many trees, however, are allowed to grow till two or even more years old.

FIG. 193—FIRMING NEWLY PLANTED GRAFTS

Center wheels pack earth beside the plants.

308. **"Incubator" boxes in grafting.**—Success has been greatly enhanced by an "incubator box," in which the grafts in bundles or in layers are packed with damp moss and kept at a temperature of 75 to 80 for about three weeks by which time callusing is good enough to permit removal. The grafts (made in the whip style) have their tap-roots shortened to six inches and are potted in six-inch pots. When a few leaves have appeared, the plants are hardened off and placed in a frame for the first year. This method has given about 75 per cent success.

309. **Root grafting vs. top grafting.**—In West Virginia, King apples top-worked on seedlings were in fairly good condition at 20 years old, whereas others root grafted and set in the same orchard

were dead at 10 years. Ten Walldow root-grafted trees were all dead but one limb on one tree (most of the 10 died between five and 10 years), but the 10 top-worked were thrifty at 20 years. In an orchard of 100 root-grafted and 70 top-grafted trees 44 per cent and 7.2 per cent, respectively, died.

For propagating apple varieties with weak trunks, top grafting or double working is recommended, Tolman sweet being preferred as a stock because of its close, smooth bark, strong, yet not rapid growth and its great longevity. [These methods are thought to aid trees in resisting disease.]

310. Top grafting, while of widest application to established orchard trees, is yet of importance in nursery practice. To the author it seems this method might be more widely utilized by nurserymen as follows:

311. Top grafting nursery trees.—C. P. Close of Maryland started summer apple trees on Northwestern Greening trees. Three to six of the best placed and strong limbs were pruned to stubs two to three inches long and whip grafted. All other limbs were cut off. The grafts were wound with waxed cord and painted with liquid grafting wax. The cion tips were also waxed. The roots were pruned back to three or four inches just before grafting and setting in the orchard. About 90 per cent of the grafts made good unions. When one failed a shoot usually developed and was budded. This method is believed to be of special use where trees of desired varieties cannot be secured or are weak growers with tender trunks. Prof. Close also suggests that nurserymen might use it to re-graft their surplus strong, healthy trees instead of burning them, or such trees could be sold at a moderate price for the fruit grower to re-graft.

In top grafting, the stock, cut usually at or above the ground surface, is either treated by the cleft or the notch method, one or more cions being inserted in the stub. Sometimes cions are forced between bark and wood. Usually the cions have only one to three buds and are rarely longer than four inches.

In orchard (less in nursery) practice unsatisfactory trees are top-worked, also trees of strong growth are used as bodies for poor straggling growers and those that have trunk weakness (309). Thus any desired variety may be worked on trees by the individual orchardist. The method is of practically universal utility, because nearly every fruit grower is sure to have at least some trees that

do not please him but which are too good to destroy—seedlings, trees untrue to name, shy bearers, others in which graft or bud has failed but a sucker developed, and so on. Any desired number of varieties may be worked upon the same tree, the number being restricted only by the available branches or stocks.

312. Cleft grafting, the method perhaps most widely employed outside of commercial establishments, finds its chief use in amateur practice to work over seedling and unsatisfactory trees to desired varieties. Everyone should know how to perform it, because there is no telling when it may become useful. Though it is, in a sense, not widely used commercially, it commands rather extended treatment in any book on plant propagation.

FIG. 194—GRAFTING AND BUDDING TOOL KIT

Reading from the left: Cleft grafting iron; shears; grafting knife; pruning knife; cleft-grafting mallet; in center below, budding knife; string cutting knife.

The stocks, one-half to two inches or perhaps even larger, sawed squarely across with a sharp, fine-toothed saw and made about six inches long, are split 1½ inches deep with a grafting iron (Fig 194) and then wedged apart until the cions, usually containing three buds, and cut wedge shaped below are adjusted with a slight outward slant, one at each side of the slit. The wedge is then gently removed so as not to displace the cions, and all the wounded surfaces thoroughly waxed over. The

advantage of having two cions is that the healing will be quicker. Should both grow, the weaker or poorer placed should be cut off cleanly the following spring.

In making cions the lowest bud should be just above, almost between, the cuts that form the wedge. When placed in the stock this bud should point outward, and when the wax is applied should be covered completely. As the sprout grows it will push through the wax.

For outdoor grafting of this kind, cion wood, always of

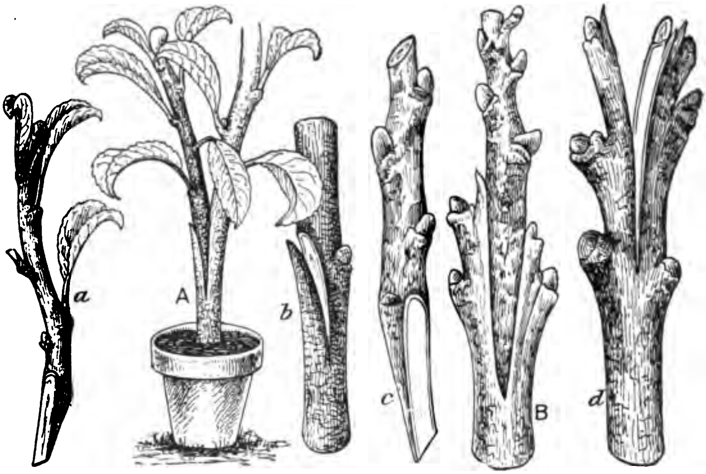

FIG. 195—SIDE AND TERMINAL GRAFTS

A, side graft of herbaceous plant complete; a, cion; b, stock enlarged; B, terminal graft complete; c, cion; d stock.

only one season's growth, should be cut while the trees are fully dormant and stored in an ice house or in some other cold place to keep the buds from swelling. The operation is best performed just when the trees are breaking into leaf. If the twigs are long and the lower buds poorly developed, these should be discarded Because cleft grafting is a rigorous operation, preference, wherever possible, should be given to stocks of one-half to one

inch, so the healing may be completed in a single season, thus lessening the chances of decay. In such cases only one cion is needed. When large stocks are used it may be necessary to keep the cleft wedged apart so as not to squeeze the cion too much. Such wedges should be placed in the heart wood and cut off even with the face of the stub.

313. Grafting irons are of two general forms; one suggesting a sickle with its point reversed and thickened to form a four or five-inch wedge, the other a straight shank with blade on one side and the wide wedge at the end on the other. (Fig. 194.) The former, usually homemade, is more of a splitting tool, useful for straight-grained wood; the latter, sold by nursery and seed houses, rather a cutting tool suitable for gnarly stocks.

FIG. 196—NEWLY SPROUTED CLEFT GRAFT
Note upward trend of twigs.

In waxing, time may be saved in cold weather if the wax is kept warm and soft in hot water. A cabinetmaker's glue pot is very handy for liquid waxes to be brushed on wounds. In weather warm enough to keep wax fairly soft, application with the hands is to be preferred, since every crevice can thus be surely filled. To prevent wax from sticking to the skin grease the hands well.

Solid wax is best applied when worked out by the hands into ribbons of, say, one-eighth inch thick. Starting at the top of the cion, the ribbon is pressed against and into the crack down the side of the stub, less being needed below than above. Next a ribbon is wound around the point where stock and cion join and pressed down well. The second cion is similarly treated. Finally the parts of the stub still exposed are covered with a spoon-shaped piece of wax, care being taken to

use plenty to fill the top one-fourth inch or more of the cleft, and to cover the edges all around. By this method much better covering, to say nothing of time saving, can be secured than by dabbing and patting the wax in place. Many grafters also put little bits of wax on the upper ends of cions if these have been cut off.

Cleft grafting is the method most used in top working large trees, a line of work practiced by many men who charge a fixed rate, usually two or three cents a stub for the number of successes toward the close of summer. When the size, condition and shape of trees are favorable and when extensive preliminary pruning is not necessary, an expert grafter can make and wax an average of perhaps 600 stubs in a 10-hour day.

In top working an old tree, keen judgment is needed to re-shape the top. It is popular opinion that never should more than a third of the top be removed and grafted in any one year; a fourth or a fifth would be better. Always the general outline of old trees should be followed and branches smaller than two inches used when possible, since the cions succeed and wounds heal best in such cases.

It is usually advisable to cut the principal stubs at relatively equal distances from the axis of the tree and then select minor side limbs. In handling trees with thick tops, care must be exercised to leave sufficient shade to protect the bark from sun scald. Better cut out all large branches that must be removed before the grafting is begun, because they are sure to develop excessively if left after the removal of the limbs for grafting. Thus bare pole-like limbs may be prevented. It is well to err on the safe side by having too many than too few stubs, because the excess may be cut out later. Young trees—say two or three years old from planting—may be top worked much more quickly, because a larger part, in fact even the whole top, may be removed at one fell swoop and grafted.

Never should a horizontal limb immediately beneath another one be grafted, because the tendency is for grafts to grow upward (Fig. 196) rather than outward. Similarly, when horizontal or nearly horizontal limbs are to be grafted, the cleft should never be vertical, always horizontal, so the growths from the cions will have the least chance of interfering. This upward tendency of cion growth explains the narrow and dense tops of top-grafted trees. Hence also the necessity for careful pruning and training to open up the tops again. Because of this necessity the folly of grafting old trees only on large interior limbs close to main trunks is apparent. Such trees become pomological exclamation points.

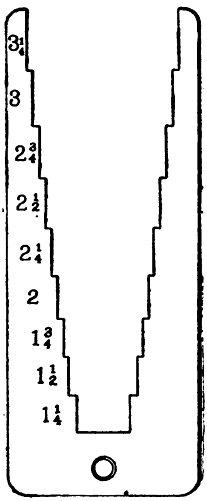

FIG. 197—LARGE TREE CALIPER

While top grafting is best performed when the buds are beginning to swell, on account of the rapid healing of wounds and the probably greater success at that time, it is usually necessary to start two or four weeks earlier and continue as much later when many trees must be worked over by few hands. Late-set cions usually get so poor a start they are weak and cannot withstand frost the following winter.

Time may be saved by having three men work as a gang, one to prepare stubs, a second to cut and set cions and the third to do waxing. The second, perhaps aided at first by the third man, makes a lot of cions while the first man is getting a start on the stubs. The cions as made are dipped in water and when placing begins, are carried in an outside breast pocket. The second man carries an 18-inch mallet (Fig. 194) handily slung by a cord from his wrist. With it one downward blow on the

knife makes the cleft, an upward one loosens the knife, a second down below drives home the wedge. The mallet is then dropped, the cions placed, the wedge removed, and so on. The third man follows to do the waxing.

From time to time during spring, summer and fall, the grafts should be examined, and those which have loosened the wax and exposed the wood should be re-waxed to prevent entrance of decay. This should be repeated if necessary the following year or until the wound has completely healed. Probably wax is better than any other wound dressing.

314. Other uses of cleft grafting.—While cleft grafting is most used in working over trees in orchards, it has other uses. Established grape vines are often cleft grafted below ground, the completed work not being waxed, and often rooted grape cuttings are similarly treated. In these cases the stocks should have clefts cut rather than split because of the gnarly wood. Should the cion fit too loosely, it must be bandaged or tied to hold it in place.

In grafting fleshy plants, such as cactus (329), cleft grafting is popular, the cion being held in position by a spine or a pin before being wound with bast or raffia. No waxing is needed. Peony roots, summer grafted, are similarly handled, but bound with wire because raffia or other vegetable tier quickly decays when buried in the ground up to the top bud. Dahlias are generally side grafted, but sometimes cleft grafted.

315. Veneer grafting, from the standpoint of union of stock and cion, is perhaps the ideal method of grafting, because the parts unite quickly and evenly and make perfect unions. As handled in America it resembles the English side graft, but has a longer stock tongue. Its chief application is to potted plants in greenhouses between November and March. Stocks which have been grown in the open air during summer are potted between late August and early October and placed in cool houses

or pits prior to the operation, which is performed near the surface of the ground. It is not necessary to head back stocks until after union is complete. As good success follows the use of dormant as of active cions, but plants growing well must be plunged in moss in a frame

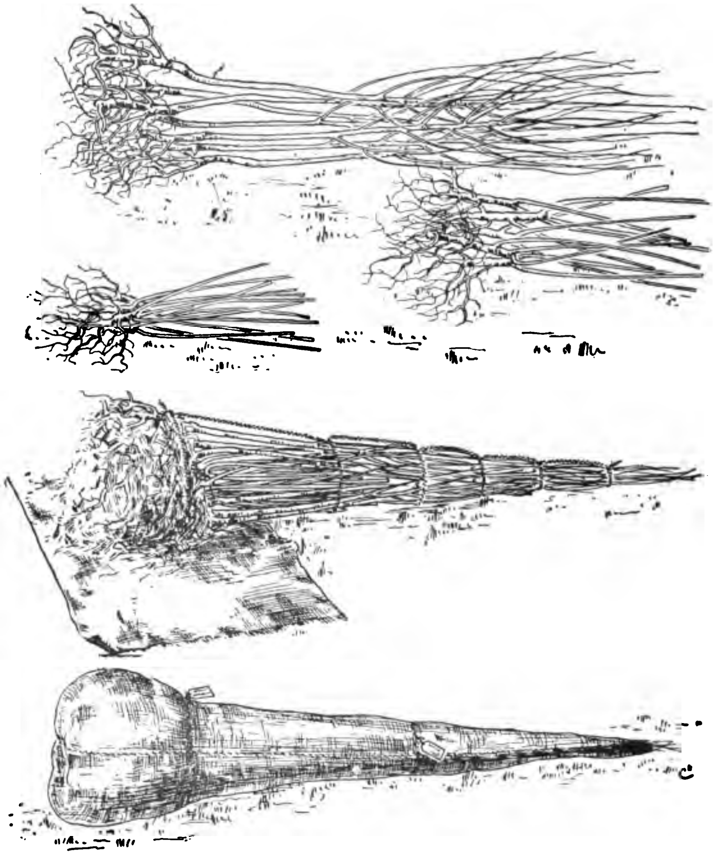

FIG. 198—PACKING SHRUBS AND TREES IN BALE

Top, trees and shrubs to be packed. Middle, trees and shrubs placed and tied. Bottom, finished bale, the trees and shrubs being wrapped in moss and covered with burlap before tying and labeling.

and kept cool, moist but not very wet, until the cions have united well.

Usually the resulting plants are kept in pots during the following summer, though some few species may be transplanted to nursery rows or open borders in spring. Japanese maples, rhododendrons and certain coniferous plants are propagated in this way. This method has the advantage that failures do not injure the stocks, which may be re-grafted as often as necessary. Few methods are more easily learned or more simple.

In preparing the stock, a cut about an inch long is made downward just through the end and the piece removed by a diagonal cut at the base, thus leaving a little notch. In this notch, and against the cut edges of the stock, the cion is made to fit by cutting in this form. Then cion and stock are fitted together, the small tongue of bark on the stock serving to cap the base of the cion when in position. Tying with raffia completes the work. Since no incision is made in the wood, waxing is not necessary, except out of doors.

316. Side grafting (Fig. 195) has several modifications, but in all the cion is inserted without cutting off the stock. In one the stock is cut as for shield budding, but instead of a bud a wedge-shaped cion is placed beneath the bark, tied and waxed. This form may be used for rather difficult subjects, either with dormant cions in spring when the leaves have appeared, or with young twigs in late summer at the usual shield budding season. By the former plan and by frequent heading in of the stock top above the cion, salable trees of such subjects as mulberries will be ready in autumn; by the latter plan plants of ornamental beech will be salable in 14 months.

In another form used in grafting small grape stocks below ground, a narrow thin-bladed chisel (preferably with a bent shank) or a knife blade is thrust about an inch deep obliquely in the stock and the cion, cut to a thin wedge as in cleft grafting, is thrust into the incision until the cut surfaces are covered by the bark of the

stock. Tying and waxing finish the work in the open air; tying alone, indoors. Heading back the stock aids union, since it throws more plant food into the cion.

In a modification of the above plan, used in root-grafting grapes and some other plants, the stock instead of the cion is cut wedge shape and is thrust into an oblique cut made upward in the cion.

317. Crown grafting or inlaying (Fig. 179) is a form of grafting in which a small sliver of wood is cut out of the stock and a cion similarly cut is fitted in its place. It has special value for grafting grapes and other "curly," grained woods. Since the necessary tying is slow, cleft grafting (312) is better for straight-grained stocks. Another objection to inlaying is that the growing cions must be tied to prevent being broken off by wind. When this care is taken the method results in good unions and excellent growth.

In the most popular form the stock, being cut off square as in cleft grafting, has one or more V-shaped grooves, large above and tapering below, and made downward, either with a knife or an inlaying tool (Fig. 179, G). In these grooves the cions cut to fit are placed and tied, and, if in the open air, are waxed. The tier should be weak and perishable, so it will decay and break before danger of strangling the cion might occur. Raffia, bast and No. 18 or No. 20 knitting cotton are all good. Winding should be very tight.

318. Modified crown grafting.—Cions bearing two buds are cut beginning just below the lower bud and on the opposite side. The stock is prepared as for splice grafting, the cion being inserted under the bark and at the tip of the stock. The union is said to form very rapidly and without enlargement.

319. Notch grafting (Fig. 179D) is a modification of inlaying, in which the stock, though cut off as in cleft grafting, is not split, and in which the wood may or may not be cut to receive the cion. It is best used in spring when the bark separates readily from the wood. In one case a saw with wide-set teeth is used obliquely downward to make one or more slots in the stock, and cions cut on

two sides to fit snugly are inserted and waxed. For best results the cut surfaces of cion should not be parallel, but slightly wider apart outside than inside, so the cions may be pressed in place both from above and from the side toward the center of the stock. This form of notch grafting has the advantage of making the cions about as firm as in cleft grafting without wounding the stock nearly so seriously.

Two other forms (Fig. 179, A), often called bark grafting, start the same way, but instead of notching the wood, the cion, in one case cut to a thin wedge, is thrust between bark and wood, tied and waxed; in the other, narrow strips of bark about one inch long are removed and the cions, cut with a shoulder opposite a well-developed bud, are set in the notches, tied and waxed. In tying it is well to use one-half-inch tape soaked in grafting wax and to bind tightly, to prevent injury by accident. Both stub and upper tips of cions should be covered with wax.

320. Smith's improved graft, an English method.—According to a writer in the *Gardeners' Chronicle,* cions of one or two-year wood of fruit trees are given a threefold grip on the stocks (one-half to one and one-half inch in diameter), which becomes covered the first year. Fig. 184 shows the defects of the old mode of "rind" grafting; Figs. 184, B, C, show the preparation of the stocks—one small, the other large. In Fig. 184, D is the finished graft waxed, and in Figs. 184, E, F, the effect of one year's growth. This plan offers more than ordinary resistance to wind.

321. Splice grafting the easiest method of all, is done by making an oblique cut across both stock and cion, as if making the first cut in whip grafting, but not forming a tongue in either part. The two pieces, being of approximately equal diameter, are placed together so their cut surfaces match and are then tied and waxed. The method finds its most useful application to small tender shoots which cannot be safely split.

322. Cutting-grafting, as its name implies, is a union of a graft with a cutting, a special case of which is root grafting already described (305). Plants hard to propagate by cuttings are often grafted upon cuttings of other varieties or related species which root readily. When the work is done outdoors in spring the grafts are usually ready to have the stocks removed by fall, the cuttings having rooted; and when done in fall under glass they are ready by spring. The nurse plant may be removed little by little or all at once, according to the case in hand. A modification of the method is to let the cion extend downward into wet moss or a bottle of water (Fig. 199). This is used where stock and cion are more or less uncongenial or are slow to unite. Various birches, magnolias and mulberries are handled in this way.

FIG. 199—BOTTLE GRAFTING

Used for difficult subjects.

323. Grafting tubes (like laboratory test tubes), about 5½ inches long and one inch wide have been used with good results for propagating shrubs and trees at the Swedish Agricultural College. Each graft-cutting is covered with a tube, the lower end of which is pressed into damp moss. Any convenient method of grafting is used (whip, splice, etc). Grafting wax was abandoned because as good results were secured without it. The plan gave good results in sand beds, flower pots and in open air. Among the subjects which did well out of doors were rose, maple, alder, birch, beech, fir, gooseberry, currant.

324. Herbaceous grafting, mainly by means of veneer, saddle and cleft methods, is very easy. Any plant with semi-succulent stems, such as coleus, chrysanthemum, geranium and the shrub-like begonias, can be grafted. Both stocks and cions should have passed the watery stage and become as firm as for the making of cuttings. After adjusting the two parts the graft should be bound with raffia, placed in a propagating frame and kept in a

humid atmosphere for perhaps a week. Wax is thus dispensed with; indeed, it is thought to be a detriment.

Some propagators bind moss around the wounds, but there is likelihood that roots will develop as in pot layering and the parts fail to knit together unless they are first bandaged. It is possible to graft shrubs and trees while the shoots are herbaceous, but this plan is not popular. Conifers (pines and spruces), and some deciduous trees (walnut) are occasionally saddle or cleft grafted in mid to late spring, bound with waxed cheesecloth and shaded with manila sacks.

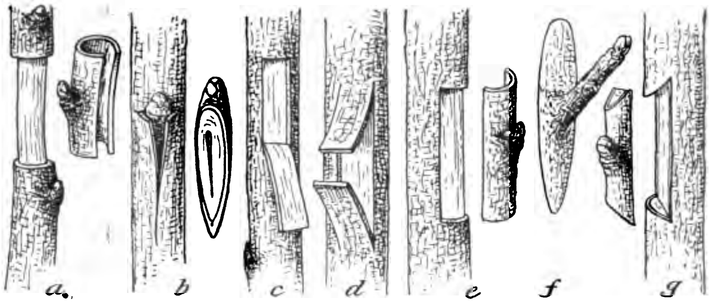

FIG. 200—UNCOMMON METHODS OF BUDDING

A, annular or ring; b, terminal; c, plate; d, H-budding; e, flute; f, prong; g, chip.

Experiments at Cornell University have shown that the wood must be somewhat hardened to secure best results. Soft, flabby shoots are likely to be injured in the operation, and the union does not occur readily. Cleft and veneer styles were most satisfactory. In most cases it is necessary only to bind the parts with raffia.

325. Grafted potatoes.—E. Laurent, a Belgian investigator, grafted light and colored flesh potatoes on each other by various methods, but after three years of experimenting found no color from a violet variety in the tubers of the light-fleshed stock.

326. Grafting beets has been experimentally done to increase the seed yield of desirable varieties. The mother beet root is sprouted. When the off-sets at the crown are about three-fourths inch long they are removed with some of the flesh and inserted in new beets just below the crown, in cuts corresponding to the form of the cions. In one experiment 48 off-sets were secured from one "mother" and 31 of these grew into first-class plants, each of which yielded a normal amount of seed.

Beets are very easy to graft, nearly every graft has been successful in European experiments. The color boundary line between stock and cion is clearly marked, red varieties not blending with white ones. Grafted beets are slightly dwarfed, as are also other plants, thus supporting Daniel's contention that one effect of grafting is to dwarf growth, another to retard the flowering season and in some cases to render plants more subject to pest attack. Potatoes with smooth, green skin and deep eyes grafted on those with thick, rough, brown skin and shallow eyes often bore both kinds of tubers, sometimes parts of each kind on the same tuber.

327. **Potato grafted on tomato** experimentally produced no tubers and the tops, although they bloomed freely, bore no seed balls. Tomato on potato bore a fair crop of apparently normal tomatoes and a few tubers which, however, did not grow when planted.

328. **Eggplant grafted.**—Van Hermann asserts that the only practical way to grow eggplant during the rainy season in Cuba is to graft it on *Solanum tortum,* a wild species employed by the Cuba Experiment Station.

329. **Cactus grafting.**—Grafting, says an Iowa experimenter, hastens the flowering season of cacti, places trailing species on strong stocks at any desired height where their flowers may be seen to better advantage. It also prevents injuries from overwatering. Healthy stocks and cions readily unite when in the actively growing season for them. The beginning of this period is best. Top working alone should be done; root grafting never, since the cion will itself strike root if in contact with soil. Cleft grafting is most popular, but whip grafting may be used with better results on slender species, and saddle grafting with thick ones. Ball species may be cut square across and the similarly cut cion fitted on top. Both should be about the same size. Strings over the cion and under the pot will hold the two in place. Another favorite way is to hollow the cion, sharpen the stock and fit the two, somewhat as in flute budding. Waxing is unnecessary. Watering should be sparingly done for a few days. Grafting greatly increases the number of flowers, hastens the flowering season and often augments plant vigor by checking the downward flow of food.

330. **Mixed graftage,** a French method, differs from the ordinary methods in that a few shoots are allowed to grow permanently upon the stock but kept pruned sufficiently to prevent their seriously checking the growth of the cion. By its means a successful union of sweet cherry (*Prunus avium*) and cherry laurel (*Prunus laurocerassus*) as a stock was readily made. This is con-

sidered a difficult one, because the former is deciduous, the latter evergreen.

Daniel, the author, concludes from his experiments that: 1. Mixed graftage should be used with plants presenting marked differences, as between evergreen and deciduous subjects; 2, the stock does not influence the

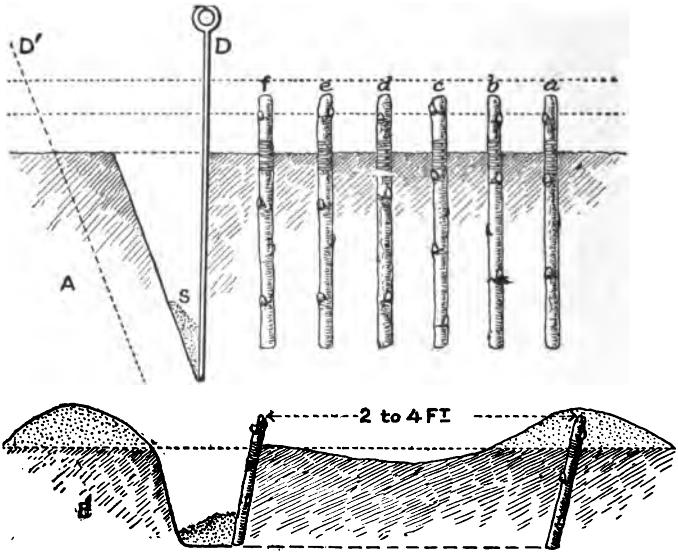

FIG. 201—GRAFT-PLANTING METHODS

A, planting with dibble; D, dibble pushing soil against graft f; D, position of dibble for next thrust of soil; S, loose soil in bottom of hole; B, planting in trenches.

cion as much as in ordinary graftage; 3, such characteristics as may be attributed to environment (height, vigor, resistance to parasites, etc.) are affected less by the stock also; but, 4, characteristics peculiar to the variety of the stock (flavor, form of fruit, color of flowers, etc.) mix with those of the cion much more readily by this method than by the ordinary methods.

331. End-to-end grafting, a new and not fully tested

French method, gave a low percentage of successes but excellent unions in California. In operating it stocks and cions of equal size are cut at slight angles (about 70 degrees), and each pair fitted together by a piece of stiff galvanized wire pushed into the pith of both parts. Bioletti considers this method "especially promising for machine grafting."

In experiments at the Good Hope Agricultural College, it was found that skillful grafters could make 300 end-to-end grafts an hour, while 100 an hour with the tongue graft was quick work. Students who had never grafted before could make 120 an hour, against 15 tongue grafts. In the field the two methods produced about equal percentages of vines when made by skillful men. Unskilled men secured almost as good results with end-to-end grafts as did the skilled men, while the tongue grafts proved almost total failures. Roots were less numerous on the cions of end-to-end grafts, thus facilitating removal. Results on the whole favored the end-to-end method.

332. Grafting green grape vines has been successfully practiced by J. Zawodny, a German experimenter, who did the work in May, June and early July, when the stocks were in luxuriant growth, by making the graft obliquely through a node.

333. Saddle grafting (Fig. 168) is especially useful for propagating small growing shoots. The cion, split by an upward cut, is placed upon the stock cut on each side to form a wedge. Tying and waxing finish the job. Its most popular application is to cions with terminal buds with wood too soft or weak to be easily whip grafted.

334. Adjuvant graft.—Couderc of France contends that the life of grape vines may be prolonged by using two stocks to one cion. His experiments show that companion stocks have a greater period of duration than either of the stocks used alone. By using a series of "adjuvant" stocks he has flowered and fruited vine cuttings the first year. This was accomplished by grafting a stock having one internode and a good root system under each eye of the cutting, which remains horizontal. The plan is suggested to overcome phylloxera attacks, which the author claims occur even with American species.

335. Fruit bud grafting.—C. Trehignand, a French investigator, has found that vigorous trees which fail to produce fruit may be grafted with fruit buds from other trees in August or September and fruit obtained the following season.

336. Grafted conifers, especially pines and firs, are never as successful as seedlings, because they rarely make a perfect leader and symmetry is sacrificed. Thuias, biotas, junipers, cypresses and ret-

inosporas may be usefully increased by grafting. Stock for first and second is American arbor vitæ (*Thuia occidentalis*); for the next two red cedar (*Juniperus virginica*); for cypress family use funereal upright cypress (*Cypressus sempervirens*); for larch use common larch.

In March on stocks established in pots use "leader" cions; cut stocks about half through, make a tongue half way down the cut. Prepare cion similarly, leaving growing point intact. Fit stock and cion accurately, bind with raffia, cover with prepared clay (285) and place under staging for a couple of days. Then smear union again with clay and plunge in a propagating case for a couple of weeks. Avoid excess of water, but sprinkle occasionally with a fine rose. After hardening place in nursery bed with soil heaped over union. To prevent annoyance from needles, cut with shears; don't pull out.

337. Mango budding, according to G. W. Oliver, an American experimenter, is best done when the new leaves are not far enough developed to show bright green, because the bark is then easiest removed. The thick part of the stem, a few inches above ground, is the best place, a rectangular piece of bark about 1½ inches long being removed for a similar piece of two-year-old wood containing a central bud of the desired kind to replace it. After fitting the bud, a light coat of liquid grafting wax, rich in resin, is brushed on and the bud tied in place with raffia. The stem just above the bud is then wound with an 8-inch strip of wrapping paper and tied in place as a protection. As stocks, moderate sized two to three-year-old seedlings are best. Stems one inch or slightly more give best unions.

Higgins of Hawaii finds that patch budding (Oliver's method) is superior to inarching, but can be done only when both bud wood and stock are in active growth, a condition rarely found in both at the same time. Shield budding with inverted T gives better results and is quicker than patch budding. It may be used when the bud wood is not in active growth.

CHAPTER XVII

METHODS OF BUDDING

338. Bud grafting is so special a form of graftage that it is generally called *budding*. It is a form in which a single bud with little or no wood is applied to the cambium of the stock (always growing in normal position), usually beneath the bark. Many species of plants are propagated by either budding or grafting; others do better by one and not the other method, but there is no general rule by which decision can be made, though thin-barked plants with copious sap generally succeed best when grafted or when buds are used at the time of smallest sap flow. Thus "throwing out," "strangulation" or "drowning" of the bud may be obviated.

Budding is widely popular for propagating fruit trees, especially the stone fruits, which are almost always budded rather than grafted. Roses, lilacs and many ornamental trees are similarly treated. In nurseries it is perhaps more extensively employed than is grafting. The usual season for budding of peach and plum in the North is from midsummer to early fall; in the South a month or six weeks earlier. Thus southern nurserymen have an advantage over northern ones, because they save practically a year's time, and the trees, if well grown, are just as good as northern grown trees. June budded trees may be fall planted in the South the same season as budded; later ones not till the following fall, because the buds remain dormant till spring.

339. Dormant budding in early spring is done to a limited extent in a few southern states. In the North, cherries and apples are usually budded in June and July, though sometimes not till August. With fully dormant buds saved as for grafting cions (307), budding may be

done as soon as the bark loosens in spring. It is essential to speed and success that the bark lift readily from the wood. Clear, dry weather also favors the work.

340. Shield budding is by far the most important method practiced in America. It is so called from the form of the bark of the cion bud—an elongated oval. In popular parlance the bud with its surrounding bark as cut is called the "bud" (Fig. 202). Essentially the operation consists in inserting a bud cut from a twig of the desired variety beneath the bark of a stock cut in the form of a T or a cross and lifted gently to receive it. The bud is then tied in place, but the binding cut in ten days or two weeks, to prevent "strangulation" of the bud, which pushes into growth when conditions are favorable. Shortly after, the top of the stock is cut off, so all food from the root will develop the budded top.

In many respects the small details differ in the hands of different budders; for instance, height and length of vertical cut, position of cross cut, cutting of bud and method of tying.

341. When stocks are budded.—Peach and other stone fruit seedlings, being of rapid growth, are usually large enough in the North to bud a little after midsummer. Apple and pear seedlings grow one year where the seeds are sown. The following spring they are transplanted to other nursery rows after the unavoidable shortening of roots. All that grow large enough between June and September are budded that season. The age of the stock is then forgotten, because it is of no consequence in the finished tree, whose age dates from the time when the buds or cions grow. Thus peach budded this year in the North in August starts to grow next spring, and by the following November has become a "one-year" tree, though 15 months have elapsed since the budding; but a tree budded in the South in June of this year becomes a "one-year" tree when only five months old in November this year. In each case the trees may be sold for fall or

for spring planting as "one-year" trees, though the southern stock is usually not ready soon enough for fall planting in the North.

Apple, pear and other transplanted stocks are "dressed" or trimmed prior to setting in the nursery; that is, both root and top are shortened a quarter or a third. This prevents the re-formation of tap roots and

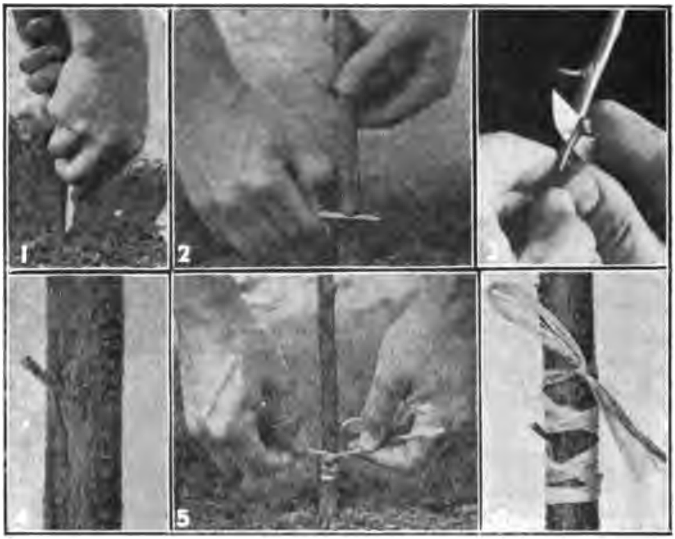

FIG. 202—THE PROCESS OF SHIELD BUDDING

1, Making vertical cut; 2, making cross or T cut; 3, cutting the bud; 4, bud inserted in stock; 5, tying; 6, finished work with bud tied in place.

makes the roots branch. It also favors the development of a sturdy top, because the number of shoots is reduced. The effect of the former development is to make a more easily dug and transplanted tree; that of the latter, one more readily handled.

342. Preparing the stocks.—To be budded without difficulty stocks should be one-half inch in diameter or larger, though in nursery practice those three-eighths

inch are also budded. A day or two before the budding, boys or girls rub the leaves and twigs off the lower four to six inches of the stems, so they will not impede the budders. If longer ahead of budding than three days, the bark will "set" and thus hinder speed in budding. Buds are set as near the ground as the operator can work —one inch or two. This brings the union so low that the unavoidable crook in the stem is inconspicuous. It also permits setting the tree in the orchard slightly lower than in the nursery. Best results in the northern hemisphere are claimed to follow setting the buds on the north side of the stocks so the sun will not shine directly on them. Doubtless in the southern hemisphere, the southern side will give best results.

FIG. 203—SECURING BUD STICKS
Such wood should be cut from bearing trees to be sure of variety.

343. Budding wood for summer work always consists of well-hardened wood of the present season's development and of the variety it is desired to propagate. The twigs, which should be about one-fourth inch in diameter at their bases, are severed from the parent trees and the leaf blades cut off. The leaf stems may be shortened to about one-half inch so as to serve as handles when the buds are being placed in the stocks. After trimming, the twigs are called "bud sticks." They may bear half a dozen to two dozen buds developed enough for use, but

the average is probably about ten. The leaf buds near the tips of the twigs are generally not mature enough to be safe to use, so they and the flower buds are thrown away. Flower buds are plumper and more pointed than leaf buds, so are easily recognized.

The buds are cut from the bud sticks with a thin-bladed, razor-edged knife, usually as follows: With the bud stick held in one hand (Fig. 202), the knife is started about three-fourths inch above or below the bud, according to the preference of the operator, and a cut through the bark into the wood is made toward the operator's body until a bud with about an inch of bark and wood is almost severed from the twig. The knife is then with-

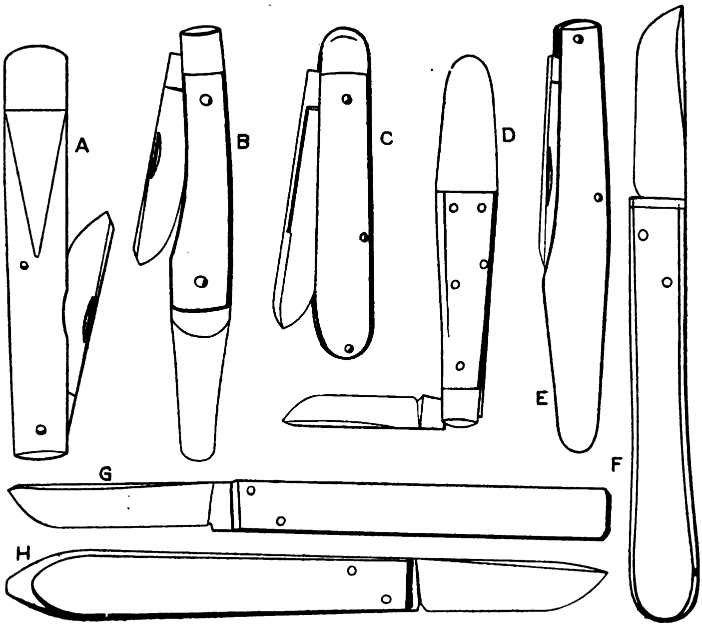

FIG. 204—VARIOUS STYLES OF BUDDING KNIVES

A, florists'; B, D, knives with closing blades and bone bark lifters; C, E, closing blades without bark lifters; F, G, H, styles of stationary bladed nursery budding knives.

drawn and the other buds treated in the same way until all that are fit for budding have been cut but left attached to the twigs. The bud sticks are then usually dipped in water, wrapped in wet cloth and taken to the nursery row for budding. Many operators prefer to cut the buds fresh as they are needed, because there is less risk of drying. The chief advantages of the plan outlined are that it saves time, and less high-priced labor than that of the actual budders can do the work. The buds as needed are cut from the bud stick with a single motion.

For years budders have disagreed as to the advisability of removing the little chip of wood beneath the bark of the bud as cut from the bud stick. No experiments seem to have been tried to prove its use or harm. Many budders pry it out with the tip of the knife blade or by twisting the stick as the bud is being cut. No difference is apparent in the resulting trees whether or not this wood is removed. It would seem that the wood might help to hold moisture until the bud has united with the stock, but that if removed the cambium layers would grow together more quickly. If the bud is cut thick, the older parts of the wood doubtless do not unite, though the younger parts probably do; so it may be well to cut at least this dense part.

344. Budding knives are of many styles, and operators have their pronounced preferences, but probably the one most used in the big commercial nurseries for field work is in Fig. 204. It costs about $1.75 by the dozen. The budding knife should be made of the finest steel, have a thin blade about two inches long; the cutting edge, kept razor sharp, should extend from front to back in a quarter circle. The blade should be set in a light, convenient handle, which may be stationary or slotted to receive it. The straight part of the blade is used for general purposes, such as bud cutting, and the curved end for making incisions in stocks. Many budding knife handles extend into a thin bone, ivory or celluloid, spatula-shaped blade

used to lift the bark of the stocks. Probably the great majority of expert budders have no use for such a device; they raise the bark with the knife blade.

345. Making the incisions.—In making a slot for the bud to fit in, two cuts are necessary. Neither must penetrate deeper than through the bark. The first is usually placed near the upper end of the second, with which it makes a cross. The second generally made extends about one and one-half inches lengthwise of the stock, the rounded end of the knife being used. Some budders prefer to place the cross cut below (270). So far as results are concerned, one is probably as good as the other. Placing the bud in position may be easier for one man to "bud up" and for another to "bud down." After the corners of bark in the angles of the cross are lifted slightly to split the bark from the wood through the cambium, the bud may be inserted and gently pressed into place by the fingers, which grasp the leaf petiole handle. If any part of the bud sliver protrudes from the slot, it should be cut off, for unless the entire piece is closely applied to the stock wood and is covered by the bark, it may make a poor union, or not unite at all, with the stock. When the bark lifts readily no such trouble will be experienced, for the bud will slip into place without trouble (Fig. 202).

346. Tying follows.—Raffia (292), the most widely used tier, is cut in lengths of about a foot prior to the work. Until raffia displaced it, bass (291) was the leading tier, though carpet warp, yarn and other soft strings were also used, and are still to some extent. The hank of raffia, held near its middle between both hands, is placed against the lower end of the vertical cut. The hands are then moved to the rear of the stock where they exchange the ends, which are made to cross each other. The crossing is repeated in front over the cut but higher up than the first round. So on till the whole cut is covered, only the bud being left visible. Three or four double rounds

complete the ligature, which is tied at the top. In another method of tying, the raffia is wrapped around the stock twice or thrice at the bottom of the bud and twice at the top, where it is tied in a single knot. Some operators can make better speed by passing one end of the raffia under the other at the last round. The bud itself must not be covered, else it might "strangle."

347. Cutting the ligatures.—Strangling may even yet occur unless the raffia around the buds is cut within three weeks of the budding. The usual way is to draw a budding knife upward through the windings on the side of the stock opposite the bud and let the cut pieces fall off. Since the tier is very inelastic, it will not "give" with the growth of the stem and the setting bud, so, unless it is cut it will either kill the bud or force it to "break," i. e., grow. For success in the cold climates, however, the bud, to winter over, must be wholly dormant until spring, otherwise it will probably winter-kill. Stocks which, at tier-cutting time, are shriveled and brown instead of green and plump, may be re-budded. If warm and wet weather in the fall starts the buds there is little remedy, though some sprouts may be saved by heading them back; others may survive the winter if covered by snow.

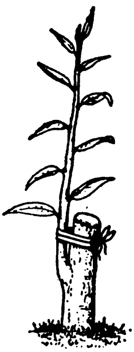

FIG. 205—BUD SPROUT TIED TO STOCK

348. Spring care of budded stock.—As soon as the stocks begin to put forth leaves in spring their tops should be cut off 4 to 6 inches above the bud, which will still be dormant. Thus all plant food taken up by the roots will be forced into the bud. In about two weeks when the bud has developed a shoot an inch or more long the stub of the stocks is cut within one-half inch above the bud. Some nurserymen cut the stocks only once,

but a larger enough percentage of successes follow the two-cutting plan to make it fairly popular.

In good soil and with a good root system, the buds, depending on the species, will develop shoots 2 to 5 feet tall, or even more by fall. Sprouts must be rubbed off the stocks whenever they appear and the bud shoot encouraged to grow straight and forkless, and all the leaves on the shoot should be allowed to remain. With crooked and weak-growing varieties tying may be necessary. For convenience in doing this work stock stubs are often left on ornamental trees, seldom on fruit trees, because of its expense, to act as stakes against which to tie the bud sprouts (Fig. 205). Except in mixed grafting (330), shoots on the stock must not be allowed to grow or they will rob the bud shoot of food and develop even stronger shoots. Toward the end of the growing season these stubs must be carefully cut close to the union of bud and stock.

FIG. 206—COLD BOX METHOD OF STORING CION WOOD

The wood is kept cold till needed. The method gives better results than the ordinary ones.

349. In "June budding," stocks one-fourth to one-third inch in diameter are favored. Instead of stripping the lower part of the stocks completely of leaves, as in northern budding, a few leaves are left below the point of budding to serve as feeders. Because of the heat of the soil surface, in hot, dry climates, it is customary to place the buds an inch or two higher than in northern practice. To avoid the sudden and violent check to growth which

would follow removal of the whole top early in the season, several cuts of the top are made so the bud shoot will not have too great a strain put upon it. Sometimes the stock tops are bent over, or broken (270), twisted or partially stripped of leaves and twigs or otherwise treated so the bud shoot will gradually accustom itself to its work. In due time, of course, the stock is cut off. The ligatures must be cut sooner than in the North, say in a week to ten days, depending on how vigorously the stock is growing. Instead of raffia or bast, strips of somewhat elastic cotton are sometimes employed as tier, because they "give" more with trunk expansion.

350. Summer budding of apples.—Apples, pears and other tree fruits are often summer budded, but the stocks have grown in the nursery row a year or two. Sometimes the buds used are dormant, having been cut and stored, like cions for cleft grafting (312), sometimes current season's growth. This plan is annually becoming more popular, partly because the nurserymen think they thus get better trees than by grafting and partly because the nurseryman is thus enabled to keep his men busy to better advantage by extending the work over a longer period. For top working trees, either those that failed to "take" the previous season or those established in orchards, this method also has its obvious advantages. The buds grow as do cions in cleft grafting, so a full season's time is gained.

351. Plate budding (Fig. 200)—Instead of making one longitudinal cut in the stock, two of equal length are made parallel. The upper ends are then joined by a cut and the bark lifted, thus forming a rectangular flap still attached below to the stock and 1 inch to 1½ inches long. A bud on a piece of bark, but with no wood, is cut to fit the space, inserted, covered by the flap which is made to cover it, and tied. From then forward treatment is the same as for shield budding (340). Two slight modifications of this method may be noted: The flap may be

split so a part may be fitted on each side of the bud, or it may be shortened so the bud itself will not be covered, but only that part of the cion bark below the bud end.

352. Prong, spur or twig budding is shield budding, modified by the use of a short spur or twig instead of a bud and removal of the upper part of the stock. The bark of both stock and cion are cut in the same way. English walnuts while dormant are often budded thus in California. This form resembles grafting in the removal of stock above bud at the time of budding, and in the use of grafting wax over wounds to prevent drying and entrance of decay. In budding thick-barked subjects, such as walnut, wood beneath the bud bark must be almost all removed, so the cambium layers will come in better contact than if it is left. The little piece of wood that extends up into the prong should not be cut out.

353. H-budding (Fig. 200) is a form of plate budding in which the cross-cut is made about midway between the ends of the longitudinal cuts, thus forming two flaps between which the bud is placed. Because the bud may thus be covered both above and below, a better fit of bud to stock can be secured.

354. Chip budding (Fig. 200) consists in cutting a mortise in a small stock and inserting a one-bud chip of bark with a little wood cut to fit snugly. This is held in position by tying, and is usually waxed. It is used while the stock is dormant in spring before the bark will slip.

355. Flute budding (Fig. 200) is a development beyond plate budding, because in it a rectangular piece of bark in the stock is removed entirely and replaced by a bud-bearing piece of bark cut to fit the space. As a rule this work is done in late spring on plants with very thick bark. Tying is, of course, needed as in shield budding (340).

356. Veneer budding, a synonym for flute budding.

357. Annular or ring budding (Fig. 200), the same as flute budding except that a ring of bark is removed from the stock, which must be rather small, by making two

parallel cuts one-half inch to one inch apart around a stock, joining these by a cut at right angles, removing the ring, fitting in a bud-bearing piece of bark and tying as in shield budding. This method is popular for budding pecan and walnut. The work is best done in summer when the bark peels readily. The buds must be taken from twigs rather younger than the stocks.

358. Whistle or tubular budding, another modification of flute budding, consists in slipping off an inch or so of bark at the end of a shoot and replacing it with a similar piece bearing a bud of a desired variety.

359. Budding old peach trees.—For old peach trees that required new wood an Australian experimenter sharpened a piece of bone like a lead pencil, fitted it to a handle, made incisions in the bark of 10-year-old trees and fitted buds in the holes. The buds were held in position by small pieces of leather, held in place by upholsterers' enameled gimp pins, which did not rust and which became loose as the buds swelled. An advantage claimed is that the method does not interfere with bearing while the buds are being matured. Neither clay nor wax is needed.

360. Stock sucker's influence.—H. M. Stringfellow of Texas found that when a peach tree was budded high (18 inches) and developed a sucker below the bud, the branch from the bud gradually failed and died. He also noted that where cions on budded stock were planted deep enough to send out their own roots, dwarfing and even killing of the stock roots followed. He therefore recommends high budding (12 to 15 inches from the ground), in order to secure long-lived budded trees, because this, he contends, will allow reasonably deep planting without burying any part of the cion.

361. Winter budding of peaches in Texas, according to R. H. Price, was experimentally done by the following method: Cuttings were taken when the sap was dormant. A slide of bark was cut down the stock, but left attached at the lower end. Part of the top of the loose strip was then cut off, the bud of a desired variety fitted over the cut place and bound on firmly with raffia. The stocks were then kept in sphagnum moss till spring, when they were planted. All but one of the 50 made strong shoots during the growing season.

362. Top working peach.—When peach trees begin to fruit and are found worthless, the question is, Will it pay to top work them? Experience has proved that usually time and money will be saved by pulling them out if over four or five years old rather than "dehorning" them, waiting till water sprouts or other limbs in desirable po-

sitions are large enough to bud, and then running the risk of failure of the buds to "take" and of possible loss through accident or disease. New trees require only three or four years to come into bearing; but at least as much time is required with top-worked trees plus the likelihood of having poorer trees in the end.

FIG. 207—METHODS OF DIGGING NURSERY STOCK

1. An extreme case of "the good old way" with nursery spades. 2. The new with steam power and wire cables.

CHAPTER XVIII

NURSERY MANAGEMENT

363. Value of nursery stock.—From the preface the extent of the nursery business in the United States may be seen. The acre return in 1909 is averaged at $261. Doubtless many nurseries paid less than this, and probably a fair proportion paid more. If 10,000 good trees can be grown to the acre and sold at an average of 20 cents (and they can be), the return would be $2,000, which, divided by four years—two for stock growing and two for rest—the income would be $500 a year. Expenses are heavy, however, partly because nursery lands usually command high rent (sometimes $100 a year), and partly because of the necessary equipment and the skilled labor needed in the business, as may be judged by the general discussion in this volume, so there is not as much money in nursery stock as may at first appear.

364. Laying out a nursery.—Since horse cultivation is necessary, nurseries should be laid out with turning ground 12 feet wide at opposite ends of the rows, and cross alleys at convenient distances both for the removal of stock and for labeling. In most nurseries the rows vary from 100 to 300 feet long, but in large ones they are sometimes a quarter of a mile long.

365. Shelters are advisable where the prevailing winds are strong. They help protect young bud and graft shoots from being broken or blown off and aid the trees to grow straight. Where natural shelter—a hill or a wood to windward—is not available, mixed shelter belts of deciduous and evergreen trees, placed beyond their root reach of the nursery rows, will serve well. Low grounds, though sheltered, are not desirable because usually frosty. Everything that will cause snow drifts among the stock should be avoided.

366. Digging stock may be done at any time the ground can be worked after the leaves fall and before the buds swell in spring, except when the temperature is below freezing. In a small way nursery spades may be used to lift individual trees. On a larger scale a furrow may be thrown away from the trees on each side of the rows and then spades used. In big commercial nurseries the tree digger (Fig. 152) is drawn by horses (Fig. 213) or by wire cables attached to drums operated by steam or gaso-

FIG. 208—MODERN METHOD OF DIGGING NURSERY STOCK

The el cables wound on the drums by the engine draw the digger from end to end of the nursery rows.

line engines. Nursery spades of steel and wood and costing several dollars each, and made strong enough to stand heavy strains, are generally worked in pairs or threes (Fig. 207) around and a foot or more from the bases of the trees. The blades, at least 15 inches long, are thrust full depth in the soil under the trees, which are lifted by leverage, care being taken to cut or break the roots as little as possible.

367. Nursery soils and their care.—Best nursery stock is usually produced on heavy soils, those in which clay rather than sand predominates. Of course, if level, so

much the better. Thorough drainage, either natural or artificial, is essential because nursery trees "don't like wet feet." At least one season prior to planting nursery stock, the land should be devoted to some (preferably inter-tilled) farm crop—corn, potatoes, mangels, cabbage, etc.—so it will have had deep and thorough cultivation. Since the nursery crop usually requires two or more years, the land must be in prime condition when the trees are started in it. Otherwise the crop will be mediocre, if not poor. Since sales of fruit trees, at least, depend upon age, size, caliper, etc., growth must be sturdy and quick; with ornamental trees and shrubs price is fixed scarcely at all by age, but more by the size of subject. Hence land too poor to produce good fruit trees may yet be suitable for producing ornamental stock.

It is generally conceded that soil which has just produced a crop of nursery stock should not be devoted to nursery stock again without a "rest"; this, too, in spite of the fact that instances of success under repeated cropping may be cited. Cherries and apples often produce a second crop of good trees without a rest between, and plums have been known to do well for 5, 10 or even more crops when the ground has been well manured. Pears rarely do well twice in succession. Nurserymen, therefore, change their land and in many cases rent what they need for terms of several years.

The New York state station, after analyzing large numbers of nursery trees, presents the following statement based upon the table condensed below:

[From the table] it will be seen that since, upon an average, it requires from three to four years to grow a crop of nursery stock, cereals make a far greater demand upon the soil than does nursery stock, and it is a matter of common observation that removal of a tree crop leaves the soil in excellent condition for cereals.

PHOSPHORIC ACID AND POTASH REMOVED FROM SOIL BY VARIOUS CROPS

	Phosphoric Acid	Potash
Nursery Stock, 11 tons	21.4	27.1
One ton		
Wheat Grain	18.4	12.5
Rye "	18.2	11.5
Barley "	16.4	10.6
Oats "	14.1	10.3
Maize "	12.7	7.7
Wheat straw	5.7	12.4
Rye "	5.5	16.0
Barley "	4.7	22.5
Oats "	4.3	21.3
Maize "	9.1	38.9

368. Effects of nursery crops on soil.—Roberts of Cornell University has published analyses of nursery stock to show what plant food is removed by the four leading kinds of fruit trees. The quantities appear in the following table:

POUNDS OF FERTILIZING COMPOUNDS NEEDED BY NURSERY STOCK

	Apples	Pears	Peaches	Plums
Nitrogen	29.07	24.83	22,42	19.75
Phosphoric Acid	10.13	7.83	5,42	4.42
Potash	19.73	13 33	11.75	11.50

The significance of these figures can best be appreciated by a comparison with those of other crops; for instance, silage corn. This crop grown in drills yields 12 to 20 tons an acre and will repeat the performance on manured land, fully as well, at least once. Yet, to quote Roberts's statement, "The amount of green corn necessary to remove an equal amount of fertilizing ingredients per acre, taking the average of the . . . nitrogen, phosphoric acid, and potash . . . removed by an acre of trees (three years' growth), would be 4,779 pounds." Nursery trees are, therefore, seen to take only small amounts of plant food from the soil. Nursery lands, it is reasoned, should supply three to ten times the plant food needed by the trees. Experience also supports

this deduction from the analyses and shows that good crops of potatoes, beans, wheat, etc., are secured after land has been "treed." Why not nursery stock? The reason is not a chemical but a physical one. The very methods of thorough and deep tillage necessary to produce good trees injure the soil texture by "burning up" the vegetable matter, a result most noticeable in heavy soils, the very ones which produce best nursery stock. As a rule no system of cover cropping and none of manuring between the rows is practiced, so there is neither protection of the soil during winter nor renewal of vegetable matter while the trees are growing—one to three or more years. Then, too, when the trees are dug their roots go too, and since the work is usually done in the fall, frequently when the ground should not be worked at all, the soil must pay the penalty; namely, puddling more or less serious the following spring and summer and refusal to "work up" again for nursery trees until after a rest in grain, hay or pasture.

369. Cover crops for nursery lands.—Since the nursery lands are usually heavy, it would seem that sweet clover should have special value in bringing them back quickly into good heart, because this plant burrows deeply and opens up the soil well besides adding considerable humus, both by its decaying roots and its tops, when these are turned under. Perhaps it would reduce the resting period to two or three years, as against three to five or even more under common practice. If cover crops, such as crimson clover, buckwheat and rye, were grown between the rows and plowed or disked under in early spring, the evil effects on the land would also be lessened. Coarse manure certainly has helped where applied between the rows in autumn or spring, but among nursery stock it is not always convenient to apply. It should, therefore, be liberally added after a nursery crop has been harvested. A second crop could thus be planted within two years with good prospects of success.

FIG. 209—UP-TO-DATE NURSERY SPRAYING OUTFIT
This apparatus sprays ALL of the young tree from collar to top at one passage on five rows.

Commercial fertilizers may often be applied to nursery stock with profit. Usually nitrogen is needed in liberal supply to insure strong growth. Considerable quantities can be secured from legumes, hence the advisability of growing a crimson clover cover crop. When the trees are showing yellowish leaves on poor spindling growth, a top-dressing of nitrate of soda or sulphate of ammonia, about 300 pounds an acre, during late spring or early summer, will help matters considerably, but the tillage should be good so the soil nitrogen may be utilized first. Nitrogenous fertilizers must be used with great caution, otherwise they may force too succulent a growth. This, especially if produced near the close of the season, might not ripen. The trees would thus be subject to winter injury, they would transplant with greater difficulty and be unsatisfactory to the planter.

370. Winter protection of nurseries.—From over 100 replies to queries concerning behavior of nursery stock in a very severe winter in the Northwest states and adjacent Canada it is deduced that the results of injuries suggest (1) the value of snow as a covering for nursery stock, (2) the advisability of planting nurseries as far as practicable on north slopes, (3) interspersing nursery blocks with evergreen windbreaks extending east and west. Next to snow as a cover is litter, for which oats, buckwheat, peas, vetches, or mammoth clover are advised as catch crops, the clover only for wet seasons.

371. Storing nursery stock in frost-proof winter quarters is popular with a majority of the large nurseries, because it is believed that the stock is in better condition to thrive when dug in the fall and stored at an even temperature approximating the freezing point than when allowed to stand in the nursery and be subjected to wide temperature fluctuations. Besides this is the great advantage that packing may be done under favorable conditions. But whether the trees are actually better when they reach the fruit grower is an undecided point.

FIG. 210—TREES IN FUMIGATION HOUSE READY FOR FUMIGATION

Enough hydrocyanic acid gas is generated in the crock from the little bag full of cyanide of potassium to kill everything in the fumigating house.

Winter storage should be at a uniform temperature of 28 to 30 degrees. At this temperature little ventilation is necessary, loss of vitality from drying is slight, the tendency to mold is minimized and packing the roots with damp material or spraying with water less.

372. Spraying nursery stock is as necessary as is spraying of fruit trees. Most of the fungous troubles and insect enemies that attack the same kinds of trees in the orchard may be expected, so the same preventives and remedies should be employed. Power sprayers are made specially for nursery work. One of these is shown in Fig. 209.

373. Fumigation house.—For nursery use the fumigation house should be a permanent structure of wood, concrete or brick, lined with gas-tight material and located some distance from dwelling houses and live stock quarters. It should be used for no other purpose, and its gas-holding capacity should be tested at least once every six months. Preferably it should have doors on opposite sides, so wagons may be driven in (Fig. 210), fumigated without unloading, and hauled out after the operation, thus effecting a saving of work and of time. Preferably one of the doors should face the prevailing wind, so the breeze will remove the gas quickly. The doors on the lee side should be opened first, to reduce the rush of gas that would occur in the reverse case. As a further precaution the means of opening should be well to one side of the door opening, so men will not have to expose themselves to the gas.

374. Fumigating cions may be the means of preventing insect troubles on nursery stock. An air-tight box, 3 feet long, 2 wide and 2½ high, contains 12½ cubic feet, for which ⅛ ounce of 98 per cent cyanide of potassium, 3 ounces sulphuric acid and 3 ounces water will be sufficient for a single charge. The box should be made of heavy and wide matched stuff and be battened at all corners. Every crack must be plugged tight with white lead. The lid, which should have at least two cleats in-

side, should fit snugly upon strips of live rubber one inch wide and one-fourth of an inch thick and provided with a hasp for padlocking when closed.

In one of the front corners a metal tube two to three inches in diameter and 18 inches long should be fastened, so it cannot shift its position and so its upper end will be, say one-quarter or one-half inch below the lid when closed. Through this the charge of cyanide is to be dropped in the glass or crockery vessel containing the acid and water placed just before the box is closed and locked. To do this a short glass tube containing the charge and closed at one end with paper or muslin tied over it is lowered by means of a string through a hole in the lid and the metal pipe already mentioned. When it reaches the liquid the hole in the cover is plugged tight with (preferably) a rubber cork. To prevent loss, this plug should be fastened with a string to the lid.

On both bottom and sides of the box, cleats one-half or three-fourths of an inch thick, four to six inches long and, say, six inches apart, should be placed "broken jointed," with spaces of one to two inches between their ends, so the cuttings will be separated a little from the box walls, and so the gas will have free circulation around the sides, top and bottom. The cions should be laid in loosely—never packed snugly. One or two racks made of the cleat stuff may be placed between layers of cuttings when the box must be filled very full.

All cions must be dry before being placed in the box, otherwise they may be damaged. Forty-five minutes is long enough to do the work. Then the lid may be lifted, the cions allowed to air for, say, 30 minutes (less if a strong breeze is blowing), and finally washed in water. Avoid inhaling the gas; it is deadly.

375. Greenhouse fumigation experiments have been conducted in rose and carnation houses at the New Jersey station with 98 per cent potassium cyanide at the rate of five-eighths ounce to 1,000 cubic feet. The tempera-

tures in the rose houses varied from 62 to 90; in the carnation houses 54 to 60. The length of fumigation was 16 to 17 minutes. Good results in destroying aphis were always secured in the rose houses, though sometimes the foliage was slightly injured; in the carnation houses, many aphis lived through the fumigation. Later experiments showed that fumigation for green aphis on carnations is not likely to prove successful at temperatures below 60 unless the three-fourths ounce of cyanide is used to 1,000 cubic feet and the time of fumigation increased to 30 minutes; perhaps not even then.

376. Nursery tree trimming.—Stockiness is one of the main points nurserymen aim to secure in their trees. To obtain this they give the trees plenty of space, usually not less than nine inches in rows three feet apart for small trees, and 12 inches and 3½ to 4 feet for large kinds which are to remain in the rows not over two years. Greater space is usually needed for longer periods. The first year the leaves should not be rubbed from the tree stems, or the trees will grow too slender and too tall. Should branching start too low, or should there be Y-crotches, trimming will be needed. By fall of the first year stock budded in the North the previous summer and that started from root grafts in the spring, should be four or more feet tall. That budded in the South in June should be as tall or taller.

In the spring the height is usually reduced to three or four feet to form the head. Some nurserymen head as low as 2 feet, or even 18 inches, to meet the increasing demand for low-headed trees. Shortly after heading back the earth is hoed away from the trunk bases and all sprouts from crowns and roots cut off. The leaves that appear on trunks and branches should not be removed, because they are needed to ripen and develop the adjacent wood and to help supply the roots with plant food. The practice of rubbing them off early in the season cannot be too strongly condemned. Trees deprived of these

leaves are forced to develop other leaves higher up, thus tending to make top-heavy, weak, spindling trunks.

Cutting off undesirable shoots on the trunk shortly after midsummer is a very different thing. By that time they will have fulfilled at least a large part of their function and can thus be spared with less disadvantage to the appearance and the well-being of the trees. Moreover, their removal at that time will not usually force extra top growth, because the trees will be busy ripening up the wood they formed quickly in the first half of the season when moisture was more abundant in the soil and conditions better favored quick development of wood.

If the cuts, in removing the undesirable twigs mentioned, are made with a sharp knife close to the trunk, they will heal over by October. When the cutting is over the fewest number of leaves on trunk and branches should be sacrificed.

377. Cost of nursery stock.—Prices of nursery stock vary almost as greatly as do the catalogs. Cultivation, fertilization, spraying, trimming, training, root pruning, method of digging and packing, age and size of tree, and a dozen other factors influence price. The cost of specimens should always be reckoned on the basis of quality. Often a high-priced tree is cheap at its price, and often a low-priced tree is expensive even as a gift. The initial cost is in most cases a mere trifle when compared to the after value of the specimen as a producer of fruit or beauty. Far better estimate the nurseryman and his business methods than compare or contrast his prices with those of his competitors. Such factors as trueness to name, plumpness and quantity of roots, and thoroughness of packing are beyond price.

378. Buying and handling nursery stock.*—In ordering one should emphasize especially the necessity of trees being true to name, thoroughly healthy, properly mature, and full of life. By the last is meant they should be dor-

*Synopsis of article in Pennsylvania Station Bulletin by J. P. Stewart.

mant but in strong, living condition when received by the grower, not shriveled or discolored, nor show other evidence of premature or improper handling. [Straight stock is specially desirable.] The union of graft or bud should be good, and the roots should be free from all evidence of woolly aphis [San Jose scale], crown-gall or hairy root disease. The particular form of propagation —whether whole or piece-root (282)—is immaterial so far as orchard growth is concerned, also the region in which the tree is produced, so long as the tree is sound and of the right variety for the locality involved.

One-year-old trees of good size [4 to 6 feet tall], neither stunted nor overgrown, are usually best. Never should they be older than two years from bud or graft. The advantages are that one-year trees usually cost less to buy, to ship and to plant, are more readily shipped and transplanted, those fit for sale are sure to be strong growers, and their heads can be formed as desired. If older trees are preferred, however, their limbs should be properly separated, well distributed around the trunk and located approximately at desired heights.

FIG. 211—APPLE TREE GRADES

XXX, at left; XX, middle, X at right. The XX grade is probably the most popular with commercial growers.

It is best to deal direct with responsible nurseries and to order early, submitting requirements to several firms for bids. The trees may be held at the nursery, subject to order at planting time. Where winters are not too severe, fall planting is advisable, otherwise plant in spring as soon as the ground is fit, though it may be done later if the trees are kept satisfactorily dormant. When re-

ceived the trees should be examined and heeled-in at once. Roots should be shortened back to 6 or 8 inches and those broken or bruised removed with a smooth cut above the place of injury. This pruning is often done before heeling-in. (Figs. 149, 169.)

The heeling-in may be done [on a large scale] by plowing two or more deep furrows, preferably east and west, so the trees can be leaned south or southwest, at an angle of 30 to 40 degrees, thus to escape sun scald. They should be completely unpacked, all straw and other material likely to attract mice removed, and then be laid along the furrow in a single row or layer. The roots and a third or more of the tops should be covered immediately with earth, which must be packed thoroughly around the roots. This covering may be done at least partly with the plow. Successive layers may be laid when needed. The place should be well drained. Where there is likely to be damage from mice, the whole area should be surrounded with furrows or ridges of earth.

379. Tree grades.—It is greatly to be regretted that the public considers mere straightness, girth and good appearance the indices of nursery tree quality, because this has largely helped to eliminate many of the best varieties of fruit from the nurserymen's lists, their places being taken by varieties that normally grow straight. Of course, the difficulty of cultivating and handling sprawling and crooked trees has also helped. No economical amount of care will make such varieties as Rhode Island Greening and Canada Red apples or Winter Nelis pears assume the straight and narrow form that Baldwin, Northern Spy and many other varieties assume with minimum attention.

Again, the demand has been for large trees, because of the belief that bearing will come earlier than with small ones. Unless trees have been transplanted or root pruned in the nursery, this is usually an error, mainly because of unavoidable root losses in digging. It is only

human nature, then, that the nurserymen grow and sell what the public demands—size and looks first rather than vigor, health and form characteristic of the variety, as well as trueness to name.

Needless to say, a first-class tree should be true to name, well grown, mature, old enough but not too old for planting, have a perfectly healed union of stock and cion or bud and have smooth, clean, bark free from blemishes and disease, have a strong, stout trunk and good roots characteristic of the variety and also free from disease and insect injury. The leaves should have been allowed to fall naturally, not be stripped off to "hasten ripening." They are needed to mature the wood. The tree will drop them at the proper time. Mere height is not alone a recommendation; far better a rather short stocky tree with numerous branches well placed low down on the trunk. Those not needed can be easily cut out, but if not present new ones may be hard to get where wanted. Young, rather than old trees, as a rule, will give better results in customers' hands and thus establish good feeling toward the nurserymen. Very slender trees are usually undesirable. Nursery trees are universally measured by height and diameter (caliper), about two inches above the bud or crown. Both dimensions vary with amount and character of trimming.

FIG. 212—SOUR CHERRY TREES

Left, XXX, 5 to 7 feet; Middle, XX 4½ to 6 feet; Right, X, 4 to 5 feet.

380. Standardization of nursery stock grades.—The following standard of grades of nursery stock, made of-

ficial by the American Association of Nurserymen, presupposes that all grades of trees shall be of fair shape, branched, and well rooted; that caliper measurements shall be taken two inches above the crown or the bud; that some exceptions may be made on such varieties as are known to the trade to be light growers (for instance, Yellow Transparent and Duchess apples, Seckel pears, English Morello cherries, etc.), or due to weather conditions which may affect tree growth, but that such exceptions shall be noted in the printed price list or the correspondence of the grower's sales.

STANDARDIZATION OF GRADES

Kind	Inch	Feet ("and up")
Apple	11-16 and up	5
Apple	⅝ to 11-16	4
Apple	½ to ⅝	3½
Apple	⅜ to ½	¾ whips included
Cherry	¾ and up	4½
Cherry	⅝ to ¾	4
Cherry	½ to ⅝	3
Cherry	⅜ to ½	2½
Standard pear	¾ and up	5
Standard pear	⅝ to ¾	4
Standard pear	½ to ⅝	3½
Standard pear	⅜ to ½	3
Dwarf pear	¾ and up	3
Dwarf pear	⅝ to ¾	3
Dwarf pear	½ to ⅝	2½
Dwarf pear	⅜ to ½	2
Two-year plum	¾ and up	5
Two-year plum	⅝ to ¾	4
Two-year plum	½ to ⅝	3½
Two-year plum	⅜ to ½	3
One-year peach, plum, apricot	11-16 and up	5
One-year peach, plum, apricot	9-16 to 11-16	4
One-year peach, plum, apricot	7-16 to 9-16	3
One-year peach, plum, apricot	5-16 to 7-16	2 ft. 5 in.

381. In packing plants for shipment, care must be taken to prevent drying out, heating, freezing and breakage during transit. For economy's sake, packages should be light and strong and the packing material light, cheap and respectively retentive of moisture or capable of resisting wet for plants which demand one or the other. For mail shipments, the most popular materials include sphagnum or chaff, oiled or paraffined paper, express paper, stout twine, pot and tree labels, shipping tags, cardboard, cor-

rugated paper and light wooden boxes. For express and freight, all the above list may be included, also burlap, baskets, crates, heavy wrapping paper, excelsior, straw, cord, rope and packing cases, the largest preferably iron bound or battened.

To save postage, as little moist packing as possible must be used. This must not be wet, or the package will be refused by the post office. Legal weights of mail packages must not be exceeded. The roots must be washed free of earth, straightened, laid close together, tops all pointing one way to form bundles of three or four inches in diameter. They must be covered with one-half inch of damp moss and wrapped first in oiled or paraffined paper, with the tops loose but the roots snugly wrapped. By rolling the bundle diagonally and turning in the corner of the paper, tying may be avoided. To finish, the bundle should be wrapped completely in manila paper; tied securely around center once or twice and across the ends, the address written on the package and also on a shipping tag, fastened preferably where the strings cross.

For basket and crate packing in warm weather, the plants are left with their tops visible in the bundles made as above and stood upright on excelsior, which is also packed around the sides. Burlap or cotton cloth is used to protect the bundles in baskets; battens serve the same purpose in crates. In cold weather the packing is increased and the tops covered completely.

Heavy shipments are packed in large boxes, the larger trees in two or three inches of damp cut straw or similar material and fastened in place with battens nailed through the sides. Small trees, shrubs and berry plants, are placed in their order of size till the box is full, packing and battens being used as necessary to fill the box solid full, so there will be no shifting in transit. After the cover is nailed on it should be marked "TOP" in large letters and the address painted or inked on with a brush.

Trees and plants so handled may be shipped thousands of miles with confidence that they will arrive in good condition and give satisfaction to buyers.

CHAPTER XIX

LAWS AFFECTING NURSERY STOCK

382. Enactments, general.—During recent years, laws have been passed by various countries and states regulating the sale and shipment of nursery stock, which must be inspected and certified by a duly authorized officer. The United States, the 48 states individually, and Canada, have such laws; but, because these differ more or less, nurserymen's associations have recently been working in conjunction with the American Association of Economic Entomologists to secure the passage of a uniform law for the United States and Canada and for the various states. At the present writing, though much progress has been made, the campaign is only well begun. A synopsis of the present operative laws of the United States and of Pennsylvania follow:

383. United States nursery stock law.—Whoever plans importing nursery stock from a foreign country should first secure a permit from the Federal Horticultural Board of the United States Department of Agriculture at Washington, D. C. A broker or a commission merchant may take out a permit in his own name or act as agent for the actual purchaser. The importer must see that each package on arrival at the port of entry bears the proper certificate of foreign inspection and also see that each is marked in accordance with the law (Sections 3 and 4). On arrival of the stock, and before unpacking or re-shipping, the Secretary of Agriculture and the proper state inspectors must be notified (Section 2, regulation 8) and given proper data. The Federal board will supply pamphlets covering all cases.

384. Nursery stock by mail from foreign countries (including florists' stock, cuttings, grafts, cions, buds, bulbs,

FIG. 213—DIGGING CALIFORNIA PRIVET WITH TEN-MULE TEAM
Note the huge curved knife below the rear wheels. This cuts the roots a foot or so below ground.

roots which may carry plant pests) may be admitted to the mails only when certified by the state or government inspector to the effect that the forwarding nursery has been inspected within the year and has been found free from injurious insects. The only exceptions to this ruling are shipments to the Office of Seed and Plant Introduction at Washington.

384. In Pennsylvania nurseries must be inspected annually or oftener. No nurseryman, agent, broker or dealer may legally sell or ship stock without inspection certificate. Fumigation certificates must accompany shipments from other states. The word "fumigated" stamped or stenciled on a certificate of inspection is not enough *per se;* it must be part of the certificate granted. Nurserymen in other states must file affidavits on blanks, supplied by the State Economic Entomologist at Harrisburg, that their stock shipped into Pennsylvania will be properly fumigated before shipment. Dealers in nursery stock will be granted certificates upon filing statements that they will buy such stock only from growers and nurserymen who hold valid certificates of inspection. Transportation companies must reject uncertified stock from out-state points.

386. Uniform nursery inspection legislation.—In substance the bill favored by the American Association of Nurserymen and the American Association of Economic Entomologists provides for a horticultural inspection board of three or five members in each state; for the appointment of these members, at least one of whom shall be an active grower of nursery stock; defines the terms "nurseryman," "nursery," "nursery stock," "dealer" and "agent"; designates the control of inspection matters, treatment of diseases in nurseries or other localities; authors' appointment of deputy inspectors, all working under the direction and control of the board, in which the nurseryman will have a voice; provides for a bond to be filed by the inspector to cover both acts and omissions of

inspector and deputy and so conditioned that if the nurseryman suffers loss by reason of an unjustifiable act of inspector or deputy, and secures a court judgment, he may get his money by collecting on the judgment against the bond; prescribes the usual duties of inspectors; provides for inspection of nurseries and the usual certificates and for appeals to the board itself should anyone feel aggrieved at the acts of the inspector.

It has been the idea to incorporate in this law enough rules and regulations to bring enforcement as near as possible on a uniform basis in the various states, and leave no more than necessary to the discretion of the local state officials.

387. **Diseases of nursery stock.**—Nursery stock, particularly pears, cherries, plums and apples, is especially subject to fungous diseases producing (1) in the case of seedlings, ripened wood, so buds cannot be inserted, or an imperfect union of bud and stock and (2) a stunted development due to the annual early loss or drying up of the leaves. These diseases can be prevented by fungicides—bordeaux especially. It costs about 25 cents a 1,000 for one-year and two-year trees, and 35 to 40 cents for three-year trees, or 85 cents to $1.00 for the three years for 1,000, or one-tenth cent each.

388. Damages from tree sales.—In New York a new law details causes for court action to secure damages for trees improperly named. Such damages may be recovered in civil action by the purchaser of fruit-bearing trees at any time prior to the third bearing year, provided the purchaser notifies the seller as soon as he has reason to believe the trees untruly named. The seller shall have the burden of proof in establishing his claim that any contract or part thereof exempting him from liability or limiting his liability was agreed to by the purchaser. In every case of sale of lots of 25 or more trees, the seller must at once furnish the purchaser a copy of the contract, which shall bear a specially worded statement, embodying the above ideas as to action to recover damages. The seller must also supply the purchaser with an itemized list of the shipment, giving name of county, state where

the trees listed were grown, age of trees, name and address of person for whom grown, if requested by letter or in writing on the contract by the purchaser at time of purchase. Within five days after receipt by the purchaser of the trees and the list thereof the purchaser shall compare and notify the seller of any discrepancy between the list and the labels on such trees.

SUGGESTED PRACTICUMS

General Hints

Studen... should be required to keep notes on each exercise, a separate sheet being devoted to each practicum.

Sketches, whenever possible, should be called for and marked according to the story they tell rather than to any art they reveal.

In many cases several drawings will be needed to show the various stages of development. Students should, therefore, leave ample space beside the first sketch, so all may be placed together.

Where time will permit, contests will be found to stimulate interest in the work. Such should be easy to arrange in making cuttings of a certain kind of plant, in potting, making root grafts, in budding, etc. The main points that count in such contests, are accuracy, neatness, speed, number of plants growing at a stated time.

In making notes of work done, tabular forms will be found helpful and concise. For instance, with cuttings the following plan is suggested by Dr. W. L. Howard of the University of Missouri:

Record of Cuttings

Name	Date Planted	No. Planted	If Callused, Date	Date Rooted	No. Rooted	Date Potted	Date Re-potted	Remarks
Geranium								
Coleus								

Seedage

1. *Sterilizing soil.*—Secure surface soil from several places where weeds have been seeding freely—fence corners, neglected barnyards, etc. Add fine sweepings of a barn floor to get more seeds. Also add sour and moldy soil, from the greenhouse so as to get damping off fungi, etc. Mix thoroughly and sift out debris. Moisten as if for potting and turn over once daily for a week or more to give seeds a chance to absorb moisture. Divide into two or more lots, one to be steamed, another baked, a third treated with formalin, others to be treated in two or more of these ways but one left without treatment. Provide each student with at least two seed pans, one to contain untreated soil, the others each a sample of soil treated in one or more of the ways suggested. Label the seed pans, place in a warm greenhouse and note the results at stated intervals for say a month. The notes taken may be marked as in an examination.

2. *Botanical classification.*—Examine a considerable number of species of seeds to determine which belong to monocots, dicots and poly-

cots. Among the best are: Alfalfa, asparagus, barley, beans, beets, broom corn, buckwheat, cabbage, canna, castor bean, clover, corn, cowpea, cucumber, eggplant, endive, fennel, leek, lettuce, millet, morning glory, mustard, nasturtium, oat, okra, onion, parsnip, pea, peanut, pepper, peppergrass, pine, pumpkin, radish, rhubarb, rye, sage, salsify, spinach, spruce, sunflower, tobacco, tomato, turnip, wheat. Weed seeds may well be included also.

Most of these will have to be soaked or even germinated before they can be handled satisfactorily. The idea should be so to familiarize the student with the truly named seeds that he can identify the various kinds in mixtures of say 50 species—this as an examination.

3. *Germination test.*—Select 50 or preferably 100 seeds from any convenient number of species of seed; place in a seed tester or in soil for sprouting; note the rate, date, number and strength of those that sprout in given times and estimate the value of the seed upon the basis of price and percentages of strong and weak seeds. (The same seeds used in this practicum may be also made to serve in other practicums if desired.)

4. *Germination studies.*—Note, 1, the length of time required by seeds of various kinds to sprout in a seed tester or preferably in baked or steamed soil. 2, Note the appearance of the seedling, what it does with its seed coats, its cotyledons, whether the cotyledons function as true leaves or only as storage organs, length of time before true leaves are developed. As an examination, seedlings of any convenient number of species may be placed before each student for identification. No "catches" should be included. For instance, should a student identify "collard" or "cauliflower" as "cabbage," he should be marked perfect, because both seeds and young seedlings of such are so closely alike that no one can distinguish one from the other.

5. *Accelerating germination.*—Divide a definite number of seeds into two equal lots and plant one treated (as below), the other untreated, side by side for comparison of rates of germination. A. Soak in water—bean, pea, corn, radish, cabbage, beet, cucumber, pumpkin, wheat, oat, parsnip, carrot, spinach, tomato, sunflower. B. Immerse in five or six times their volume of strong sulphuric acid in a test tube or wide-mouthed bottle and stir or shake till all the seeds are wet. Let stand 5 to 20 minutes, then wash in preferably running water for fully five minutes. Plant at once. Kentucky coffee tree, cotton, honey locust, locust, Abyssinian banana, canna. C. Pour enough boiling water to cover, say, a pint of seeds and allow the whole to cool in a closed vessel. Select samples for the class to compare in germination with dry seeds of the same kinds. D. File or cut notches in canna, moon flower, Abyssinian banana, wild cucumber, morning glory and lotus. Plant these side by side with untreated seeds. E. Soak peach, plum, cherry, walnut, butternut, hickory and similar two-valved, hard-shelled seeds a few days; freeze and thaw part of them several times and plant some of each lot in comparison with dry ones.

6. *Re-germination of seeds.*—Select 100 or 200 seeds of, say, 10 kinds of seeds—wheat, oats, peas, beans, corn, radish, dandelion, melon, onion, pepper, spinach, tomato, buckwheat, clover—and germinate them. When the sprouts are one-half to three-fourths inch long, dry them in an airy drawer for, say, a week. Rub off the brittle sprouts and re-germinate. Note how rapidly or slowly this occurs, also how many times it may be done with the various species.

7. *Large vs. small seeds.*—Count 100 large and 100 small seeds from an unwinnowed sample of, say, radish, turnip or mustard—the

first preferred—and sow them thinly in rows side by side in a greenhouse bed or out of doors. Make careful notes to determine whether or not there are individual differences in favor of one or the other, also whether one set of differences might outweigh the other set in value to a business grower.

8. *Pricking out.*—With small wooden dibble, cut at the end to form a V about one-eighth inch across and one-fourth inch deep, lift seedlings of begonia, mignonette, pansy, etc., from the seed pans and space them about an inch apart each way in flats filled with loose, fairly rich soil; water, place on greenhouse bench and shade with newspaper a few days.

9. Fill flats with soil. Use a spotting board and a dibble to mark holes one to two inches apart; lift cabbage, tomato, pepper, eggplant or similar sturdy growers from their seed pans or flats and prick them in with the dibber, first making a hole deep enough to hold the roots, second placing the plant in the hole, third, pressing the soil against the roots from bottom to top. When flats are full, place on greenhouse bench, water and shade.

Layerage

10. *General note.*—Outdoor subjects can be treated only during the growing season; many indoor ones may be used to demonstrate the principles.

11. *Simple layers.*—Compare rates of rooting of subjects whose stems are twisted, notched or cut at the nodes with those not so treated. Which makes best plants in least time with various subjects—currant, gooseberry, golden bell, mock orange, deutzia, etc.?

12. *Tip layers.*—Bury and anchor black raspberry tips and dewberry canes at various stages of development and note what stage is necessary for securing new plants. Also bury some stems, as in simple layering, to see if they will take root. How many plants can be secured from one cane, and in what ways?

13. *Compound or serpentine layers.*—Bend last year's canes of a vine so alternate parts each containing a node shall be buried or in the air. Wound the under sides of the buried nodes on some canes, but leave those on others unhurt. Note the time required to secure rooted plants by both methods. Vines to use: Grape, trumpet and Virginia creepers, Dutchman's pipe, Boston and English ivy, etc.

14. *Continuous layers.*—In shallow trenches cover shrub branches or vine canes completely except a few joints at the tips. Some may be wounded, as above (11), others not. Use very light soil or a mixture of moss or muck and soil in some cases, to cover the canes and compare with the ordinary soil of the trench. Snowball, high bush cranberry, low-growing willows, red osier (*Cornus stoionifera*).

15. *Mound layers.*—Have each class, 1, cut back bushes to develop numerous shoots for mound layering the following year; 2, make mound layers of the shrubs cut back the previous year; and, 3, dig and cut apart the rooted layers the next spring. Thus, if the plants are in three adjacent rows, each class will need only one practicum period of two hours to cover the whole method, part of the time to prepare or cut back the subjects in one row, part to bury the stems similarly produced in the next, and part to finish the work. Gooseberry, Paradise apple, quince and shrubs as above (14).

16. *Chinese, air or pot layers.*—Notch, girdle or ring stems of leggy or branchy plants in humid greenhouse, bandage with a bunch of wet sphagnum in cotton cloth and keep moist till roots have formed.

Then discard bandage, cut stem close to wound, remove some leaves, and plant in flower pot. Suitable subjects: Dracæna, pandanus, rubber plant, croton.

17. *Runners, stolons and off-sets.*—Anchor rosettes of leaves produced by strawberry, buckbush, houseleek, etc., in soil outdoors or in greenhouse and sever from parent plant when rooted. Compare plants grown thus in pots with those grown near-by in the open ground or on greenhouse bench.

Separation

18. Cut a bulb of each class in half from top to bottom and another from side to side, each through the center. Make drawings to show formation of various parts. (Easy and cheap bulbs: 1, tulip or hyacinth, 2, tiger or Easter lily, 3, crocus or gladiolus.)

19. After tops have died down in spring and any time until midautumn, dig up bulbs of any spring blooming bulb. Note and make drawings of the way bulblets are produced.

20. Do same with various lily species.

21. In fall, when tops of gladiolus, montbretia, tigridia, and other summer blooming bulbs have turned yellow, do same thing.

22. In midsummer collect bulblets in leaf axils of tiger lily, make cross and vertical sectional drawings of some and plant others in moist soil at various depths from surface to three or four inches deep. Note results.

23. Wound and handle bulbs as described (115) and note results. (Classes in consecutive years may do various stages of work as suggested under exercise in mound layering.)

Division

24. In spring, dig up and cut in pieces with spade large clumps of rhubarb, phlox, iris, etc.; plant the cut parts and note results.

25. In fall dig up clumps of canna or dahlia, store in dry warm quarters till late winter, then cut apart so each piece will have at least one "eye" or bud, and plant in pots in warm greenhouse.

26. From late August to early October dig up, divide and plant peony clumps.

27. In spring cut up clumps of plants mentioned in 24, but by method given in 25.

Cuttings

28. In autumn, after the leaves fall, make cuttings of mature wood, bury some tops up, others tops down out of doors and side by side; store some in various media (sand, dust, moss, powdered charcoal) and some uncovered in a humid, cold but frost-proof cellar; make other cuttings in spring, bury some butts up, other butts down for two or three weeks; plant all lots side by side, previously having made notes of their condition. Show in tabular form the results secured after six weeks or two months' growth outdoors. Choose both easy and difficult subjects; willow, alder, maple, elder, currant, hickory, apple, pear, quince, Japanese plum, American plums of several species, European plum, peach, poplar, elm, catalpa, gooseberry, lilac, grape, etc.

29. *Root cuttings.*—In fall dig well-established blackberry or red raspberry, "stool" at least a foot from the outside all around; shake out earth; cut roots of one-eighth to one-half inch in diameter

into two-inch lengths; store in green sawdust in cold, humid cellar till spring; then plant horizontally an inch deep in sand.

30. Fill up hole left in 29; thrust spade full depth of blade vertically in soil at intervals of six inches from hole so as to form circles around the hole and thus cut the roots that remain; compare plants so produced with those made as in 29.

31. Secure cuttings as in 30, but after a month's callusing grow in greenhouse. Compare with plants of 29 and 30.

32. In spring root prune, but do not remove "stool," by making three or four circles with the spade around the stool as in 30. Note results.

33. *Tuber cuttings.*—Cut an Irish potato into pieces so each piece will have at least one "eye," another a good deal of flesh, a third very little flesh, a fourth cut through the middle of a good bud. Note differences in plants produced, and if desired, in resulting crop.

34. Cut a tuber from end to end and from side to side, plant the pieces shallow in sand near together and note any differences.

35. Plant one sweet potato whole, another cut in half lengthwise and a third crosswise in warm greenhouse or hotbed, the cut pieces cut side up and down respectively. Cover with half inch of sand. Note results and any differences.

36. *Greenwood cuttings.*—Make "soft wood" cuttings of any greenhouse plants available, part cut at, part just above, and part just below nodes; leave all leaves but the bottom ones on some; remove all but the top two or three on others; on still others, remove bottom ones and cut back the others fully two-thirds, leaving the growing tip bud in each case. Shade some with paper, leave some unshaded. Vary the experiments otherwise as desired and note results.

37. *Evergreen cuttings.*—In October make cuttings of arbor vitæ or spruce four or five inches long. Cut (don't pull) off foliage from three-fourths of the base, plant in flats of sand immediately and set away in cool place. Keep shaded, moist, not wet. If out of doors, examine to see if rooted six to twelve months from planting. If indoors with bottom heat they may root in less than two months. Try both plans and decide which is the better and why.

38. *Mature wood cuttings.*—In fall make two and three bud cuttings of grape from last season's growth. Bundle up, label and bury, or store in damp moss, etc., to callus. In spring plant some obliquely, some vertically, some with two buds and some with only one bud showing, in a frame out of doors or in the open field. Note differences.

39. Cut similar canes (38) an inch or so on each side of a bud to make single-eye cuttings less than three inches long. Bury and handle as above, except that in planting place some cuttings with the eye in various positions from horizontal to vertical and at varying depths in the sand down to, say, three inches. Note differences.

40. Make heel and mallet cuttings and handle as in 38.

41. Compare mature wood cuttings of Americana, domestica, Mariana, triflora and other species of plums. Which strike root most easily?

42. After making cuttings as in 38, store some under varying conditions of moisture and temperature. Which conditions produce best results?

43. Plant some cuttings made as in 38 in fall where they are to remain. Mulch some, but leave others bare. Compare each lot with the other, and at close of growing season with plants produced by the 38 method.

44. *Leaf cuttings.*—Make leaf cuttings of rex begonia by both methods described (191).

45. Lay bryophyllum leaves flat on sand in propagating bench. Place a little sand on each to hold in place. Note differences between wounded and unhurt leaves.

46. Bury stems and one-third of gloxinia leaves in propagating sand. Take up and examine various specimens at intervals of a week or two until little bulbs are formed.

47. Try the same experiment, but with the upper halves of leaves.

48. Try similar experiments to those of 44 with cabbage and lemon leaves.

49. *Plants produced by leaves.*—Fasten a mature leaf of bryophyllum on the wall or a post in a humid greenhouse and leave undisturbed a month or six weeks. Make notes of what happens. Try other leaves at the same time in a dry room and make comparative notes.

Potting

50. Try planting in wet pots; dirty pots; new, dry pots; new pots soaked overnight but dried so no water is visible on them. Also with soil so dry it will pour; soil so wet it will form a clod in the hand, and soil "just right."

51. B. Lift seedlings with as many roots as possible from previously watered flats and plant in two-inch pots. Place on one-half inch of sand in greenhouse bench, water and shade.

52. Lift cuttings from propagating bench when they have roots, preferably about one-half inch long, plant as in 51.

53. Water a lot of plants sadly in need of shifting from two-inch pots to a larger size several hours before, others immediately before, and others not until after shifting to three-inch pots. Note differences in ease of handling and results in plant growth. After two to four weeks make critical examination of roots and soil in pots treated each way. Describe findings and draw conclusions.

54. Re-plant some plants purposely allowed to become pot-bound; 1, by gently or forcibly breaking the soil and re-potting; and 2, by washing out the soil before doing so. Compare the methods.

Grafting

55. In November or December from correctly named bearing trees select cions six to nine inches long, some among the bearing parts, others from water sprouts (not the suckers). Store until ready for grafting.

56. Make enough grafting wax to supply needs of class for all kinds of work during college or school year.

57. In midwinter make some whole-root, some piece-root grafts, using some of each class of cion wood in 55. Store finished grafts till spring. Note differences between the two classes of wood, both in grafting and in later results.

58. In spring plant root grafts made in 56.

59. In spring when the buds begin to swell make cleft grafts using some of each class of wood secured in 55. Make examinations of work each week for at least a month. Some of these grafts may be made at the crowns of trees that failed to take buds the previous year, others among the tops of trees in bearing.

60. Similarly practice bark grafting.

61. Similarly practice the notch method.

62. Toward spring confine some rabbits or mice around the trunks of seedling or worthless apple trees 3 to 10 years old, and if necessary by withholding food force them to girdle the trees. When the wounds are large enough remove the rabbits and protect the wounds from drying out till the buds of peach and other trees earlier than apple begin to open, then bridge graft.

63. In the greenhouse or out of doors, practice inarching on any convenient plants.

64. *Herbaceous grafting.*—Select vigorous, potato and tomato plants of early varieties about nine inches high. Cut the former stems square across about four inches above ground and split them about 1½ inches downward. With a sharp knife cut a four-inch tomato cion from the growing tip and make its lower end wedge-shape, to fit the cleft in the potato stem. Tie snugly with raffia and wrap with damp sphagnum. Shade a few days. Note results weekly till the plant matures or dies. Perform a similar operation with tomato as stock and potato as cion. Make critical notes.

65. *Callusing of grafts.*—Make grafts of various kinds—splice and cleft at the collar, whip on root, side on root—and after wrapping or waxing according to the method employed, cover with two or three inches of moist sand on the greenhouse bench. In a week or ten days note what has happened and make comparisons. If thought desirable, plant in five-inch pots a week or two later and note results still later.

66. *Making and storing root grafts.*—In autumn or early winter, make any convenient number of whole-root and piece-root grafts; tie in bundles of one kind each; label with variety name, date and student's name, pack in moist sand and store in a cellar till spring. Make notes; plant and continue note taking as to development and comparison as to growth.

Budding

67. Practice dormant budding in spring on seedling stocks growing in nursery rows one or two years.

68. In midsummer, or somewhat later, select bud sticks from truly named peach trees and shield bud in seedling stocks grown during the same season.

69. In June or early July practice the same method on apple or cherry stocks.

70. Within two weeks cut the raffia around all but one or two of the best-looking buds. Make examination of each at intervals of a week and note results.

Packing Plants for Shipment

71. *Mail shipment of plants.*—Place the washed plants with their roots parallel and together in a close pile. Cover all around with, say, one-half inch of sphagnum. Wrap with oiled paper and tie with string at each end. Cover with manila paper, tie with stout cord. Write address on package and also on a shipping tag to be fastened to the package. A test of good packing is to have the plants in good condition a week or ten days later when unpacked.

72. *Packing express shipment.*—Tie loose plants (e. g., cabbage, tomato) in bundles of 10, 25, 50 or 100, so as to be easily counted and not to be too bulky—say four or five inches in diameter. Have a little wet moss in the center of each bundle. If plants are in pots, water

freely an hour or two before lifting. Roll each bundle separately in paper in such a way as to need no tying. Place one-inch layer of damp, not wet, moss on bottom of proper-sized basket. Stand bundles upright and close together on moss. Pack moss between bundle and sides of basket. If plants are short, cover with burlap sewed or tied on; if tall, draw tops together, cover around sides, leave open at top in warm weather, but in cold cover all. In cold weather a closed box is a better package.

73. *Packing plants for mail delivery.*—Pack several kinds of plants from three to four-inch pots to go by mail (see Exercise 71). Place a package in each of, say, three or four sets of adverse conditions likely to be encountered in an actual shipment—a hot, a cold, a dry, a moist room—during a week. Then unpack, note results and see how many plants will grow when planted under favorable conditions.

74. *Pack bale of trees or shrubs for freight or express.*—Select dormant trees or shrubs of various sizes. Tie and label each variety separately. Dip roots of each bundle in thin mud. Lay large trees on floor or ground first; fit smaller ones in; tie with binding twine; on floor spread burlap big enough to cover whole bundle; put wet chaff, sphagnum or sawdust three inches deep where roots are to be; place roots on this, draw up sides of burlap and fill in more packing where needed to make three-inch packing all around roots; sew together or use three-inch nails as pins; tie with rope or stout binder cord; fasten on two addressed tags in different parts of the bundle.

75. *Box packing for cold weather.*—Tie dormant trees as in bale packing. Treat active plants as in basket packing. Line a box with two or three thicknesses of paper. Cover bottom with three inches of moist chaff or sphagnum. Place large tree bundles on bottom, nail one-inch boards through box sides to hold trees from shifting. Place shrubs and fasten similarly. Cover with two or three inches of damp, cut straw. Lay in the active plants previously wrapped and fasten so they won't shift during shipment. Fill two inches of the top with packing. Be sure to make box contents feel solid with packing before nailing on cover. If packing is too wet, there is danger of heating. It should be merely moist.

76. *Heeling-in.*—In a trench one foot deep and wide and any desired length, place fruit tree roots, tops pointing obliquely to south side. Cover with earth from the other side of the trench and pack firmly. Place other rows of trees, then shrubs and lastly berry plants—even strawberries. Cover tops of trees and shrubs wholly with soil. Stake position of rows. Leave no material that will serve for mouse nests. In spring note results.

TABLE I

ANNUALS AND PERENNIALS GROWN FROM SEED

CONDENSED CULTURAL INSTRUCTIONS

For Flower Seeds*

The letter opposite the plant name refers to the proper paragraph in the list which follows.

Abronia	A
Abutilon	N
Acacia	S
Achillea	V
Acroclinium	M
Adlumia	G
Adonis	F
Ageratum	F
Agrostemma	A
Alyssum	F
" perennial	V
Amaranthus	A
Ampelopsis	V
Anchusa	V
Anemone	V
Angelonia	N
Antirrhinum	A
Aquilegia	V
Aralia	N
Arctotis	A
Aristolochia	V
Arnebia	A
Asparagus Verticillatus	V
" plumosa	S
" Sprengeri	S
Asters	A
Auricula	C
Balloon Vine	F
Balsam	A
Bartonia	U
Begonia	S
Bellis	C
Bignonia	V
Brachycome	F
Browallia	A
Bryonopsis	F
Cacalia	U
Calampelis	A
Calandrinia	P
Calceolaria	B
Calendula	F
Calliopsis, annual	F
Campanula	V
Canary Vine	F
Candytuft	U
" hardy	V
Canna	O
Canterbury Bell	V
Carnation	T
Celastrus	V
Celosia	A
Centaurea	U
" white-leaved	Q
Centrosema	V
Chrysanthemum, annual	U
" perennial	T
Cineraria	B
" white-leaved	Q
Clarkia	U
Clematis	V
Cleome	F
Clianthus	D
Cobæa	D
Coccinea	F
Cockscomb	A
Coleus	D
Collinsia	U
Convolvulus	F
Coreopsis, hardy	V
Cosmos	A
Cowslip	C
Crepis	U
Cucumis	F
Cuphea	A
Cyclamen	B
Cypress Vine	F
Dahlia	O
Datura	F
Delphinium	V
Dianthus, annual	U
" hardy	V
Digitalis	V
Dimorphotheca	A
Dolichos	F
Dracæna	N
Echinocystis	F
Edelweiss	V
Eschscholtzia	U
Euphorbia	F
Ferns	S
Fuchsia	N
Gaillardia	F
" perennial	V
Geranium	N
Geum	V
Gilia	U
Gladiolus Seed	O
Globe Amaranth	M
Gloxinia	S
Godetia	U
Goldenrod	V
Gourds	F
Grevillea	N
Gypsophila	F
" hardy	V
Helichrysum	M
Heliotrope	N
Helenium	V
Heuchera	F
Hibiscus, annual	F
" hardy	V
Hollyhock, hardy	V
" annual	A
Honeysuckle	V
Humea	Q
Humulus	F
Hyacinthus	O
Ice Plant	A
Impatiens	N
Incarvillea	U
Inula	V
Ipomœa	F
Ivy, English	V
Kaulfussia	U
Kenilworth Ivy	V
Kochia	A
Kudzu Vine	V
Lantana	N
Larkspur, annual	U
Lathyrus latifolius	V
Lavatera	F
Lavender	V
Layia	U
Lemon Verbena	N
Leptosiphon	U
Linum	U
Lobelia, annual	Q
" hardy	V
Lupinus	U
Lychnis	V
Malope	F
Mallow	F
Marigold	F
Marvel of Peru	F
Mathiola	F
Matricaria	D
Maurandia	D
Mesembryanthemum	F
Mignonette	U
Mimosa	D
Mimulus	D
Mina	J
Momordica	F
Moon Flower	F
Morning Glory	F
Musa	K
Myosotis	C
Nasturtium	F
Nemesia	N
Nemophila	U
Nicotiana	D
Nigella	U
Nolana	U
Oenothera	A
Oxalis	F
Pæonia	V
Palava	U
Pansy	C
Passion Flower	N
Pelargonium	N
Pennisetum	F
Pentstemon	V
Perilla	D
Petunia	D
Phlox, annual	F
" hardy	V
Physalis	A
Pinks, annual	U
" hardy	V
Platycodon	V
Polyanthus	C
Poppy, annual	P
" hardy	V
Portulaca	F
Primula, tender	B
" hardy	C
Pyrethrum, hardy	V
" golden-leaved	Q
Rehmannia	N
Rhodanthe	M
Rhodochiton	N
Ricinus	F
Rocket	V
Rose, monthly	I
" hardy	V
Rudbeckia, annual	U
Salpiglossis	A
Salvia	A
Scabiosa	F
" perennial	V
Schizanthus	F
Silene	F
Smilax	N
Stevia	A
Stocks, annual	A
" biennial	I
Stokesia	V
Sunflower	F
Swainsonia	S
Sweet Pea	E
Sweet Sultan	F
Sweet William	V
Tagetes	F
Thunbergia	F
Torenia	D
Tritoma	O
Tropæolum	F
Valerian	V
Verbena	A
Vinca	N
Violet	C
Virginian Stock	U
Viscaria	U
Wallflower	V
Wistaria	V
Zea	F
Zinnias	F

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GENERAL RULES

To avoid repetition in the lettered rules below, the following general rules and notes have been cut from the Henderson original directions:

Where mentioned as necessary to grow seedlings, flats should not be over 2½ inches deep.

Seeds should be covered not more than four times their diameters.

Unless otherwise stated, seeds should be firmed in the soil, as shown in Fig. 7.

Never let seedlings become dry.

Transplanting of seedlings is done when two or three true leaves have formed.

A Sow in flats in greenhouse, hotbed, or light window of dwelling in temperature of 60 to 70 degrees. Cover and firm the seeds. Water with fine spray. Transplant 1 inch apart in similar flats or 2-inch pots. Plant out in garden after danger from frost. Seed may also be sown in open ground after danger from frost is over.

B Sow in flats of light soil in greenhouse, hotbed, or light window, in temperature of 50 to 60 degrees, at any time except during hot weather (spring months preferred). Merely press the seed into the soil with firming board; rub a little light soil through a fine sieve over them until covered not deeper than 1-16 of an inch. Water with fine spray. Transplant 1 inch apart in flats. Pot off as soon as large enough. Shift as pots fill with roots until the sizes of the pots are 6 or 7 inches.

C For early flowering, sow in fall in bed of fine, well-pulverized soil. Cover and firm the seed. Transplant about 2 inches apart in cold frames; cover with mats during very cold weather. Sow also in spring in flats, in temperature of about 60 degrees, and transplant 1 inch apart in flats. Plant in the open as soon as frost has left the ground. The plants succeed best in a moist, loamy soil, partially protected from hot sun.

D Sow in light soil in flats, placed in hotbed, greenhouse, or window, in a temperature of 60 to 70 degrees. Cover seeds and press firmly. Water with fine spray. Transplant 1 inch apart in flats. Plant out in open garden after danger from frost, or pot in 2-inch pots and plant out from these, or shift into larger pots as the plants need root room—this last provided large plants in pots are desired.

E Sow in spring in open ground where plants are to grow, in deeply prepared soil. The sooner sowing can be done the better. Thin seedlings to 6 inches apart. Moist, loamy soil gives best results. Seeds should be 2 inches deep in soil; in lighter soil they should be 4 or 5 inches deep, and the soil should be well firmed upon them. If not allowed to go to seed they will flower much longer.

F Sow out of doors in well-pulverized soil when danger from frost is over. Cover and press soil firmly. Thin out so the plants are not crowded. If desired, early seed may also be sown in greenhouse, hotbed, or light window of dwelling. Transplant to flats and plant in open ground after danger from frost is over.

G Sow in spring in open ground where plants are to remain. Cover and firm, and thin seedlings as necessary so they do not crowd. Protect roots in winter by covering of leaves or straw.

I Sow in flats of light soil in greenhouse or hotbed. Cover and firm. Transplant in flats and plant out in open ground after frost danger is over. If sown early, they will flower the first year; if not, they will have to be taken up, in cold localities, potted off and kept in cool greenhouse, or heeled in in protected frames during winter. Sow also in well-pulverized bed in open ground in spring or summer, and care for in winter in the same way.

J Sow in light soil in flats in warm greenhouse, hotbed, or light window of dwelling. Cover. Transplant to flats 1 inch apart. If profusion of flowers is desired, pot off when about 1 inch high into 2½-inch pots and allow to become pretty well root-bound, to check luxuriant growth and throw the vigor into flowers. Plant out in garden after danger of frost is over.

K Plant seeds in flats about 1 inch apart and ½ to 1 inch deep, in light soil mixed with cocoanut dust, leaf mold, or well-rotted manure. Place in warm situation at temperature of not less than 70 degrees, either in greenhouse, hotbed, or window. When seedlings are large enough, pot off singly into small pots, and shift into larger ones as necessary.

M Sow out of doors when danger of frost is over. Cover, press firmly, and thin out seedlings to prevent crowding. If desired early, sow in flats in greenhouse, hotbed, or light window, in temperature averaging 70 degrees, and transplant to similar flats. If desired to keep flowers as everlastings, cut when buds are a little more than half open and suspend in a dark, dry place with heads down until fully dry.

N Sow in flats of light soil in greenhouse, hotbed, or light window of dwelling house, in temperature averaging 65 degrees. Cover, press firmly, and transplant seedlings 1 inch apart into similar flats. Water with fine spray. Pot off as soon as large enough, and repot, as they grow, into larger pots; or they may be planted out in open ground for the summer, after danger of frost is over.

O Sow in flats of light soil in greenhouse, hotbed, or light window of dwelling, with an average temperature of 65 degrees. Transplant 1 inch apart to similar flats, and plant out in garden after danger of frost is over. In fall, take up roots and store in sand in cool, dry place, such as cellar. Sowings may also be made in open ground in spring, after danger of frost is over.

P Sow in open ground after danger from frost is over, in beds of well-pulverized soil. Plants should remain where sown, as they will not stand transplanting unless done with extraordinary care. Thin out carefully, so as not to disturb the remaining plants more than necessary. For succession of blooms, two or three sowings may be made at intervals during summer.

Q To get good sized plants for planting out in the spring, sow seed in flats in greenhouse, hotbed, or light window of dwelling as soon after January first as possible, in light soil, in temperature averaging 60 degrees. Cover, firm. Transplant to similar flats 1 inch apart. When large enough, pot in 2½-inch pots. Plant in open ground after danger from frost is over.

S Sow in flats of light soil, in temperature of 70 degrees, in greenhouse, or light window of dwelling. Merely press seed into soil. Always water with fine spray, so as not to disturb the surface. Place pane of glass over top, but allow a little space for ventilation. Put flats in shaded place. Transplant to similar flats and pot off when large enough.

T Sow in spring in greenhouse, hotbed, or light window of dwelling, where temperature will average 60 degrees. Use flats of light soil. Cover. Transplant seedlings 1 inch apart in flats. When 1 or 2 inches, pot in 2½-inch flats, and shift to larger ones as needed, or plant in open ground, where plants will form flowering clumps for fall and winter.

U Sow out of doors after danger from frost, and, for succession, at intervals during summer. For early flowering, sow in greenhouse, hotbed, or south or southeast window of dwelling, in flats, with average temperature of 60 degrees. Transplant to similar flats and plant seedlings in open after danger from frost is past. Also sow in garden in May in light soil; cover, firm, and water with fine spray.

V Sow out of doors after danger from frost is over, in beds of finely pulverized soil. Cover with light soil and firm. Thin out when necessary. Plant in permanent position as soon as seeds are large enough, so they may become firmly rooted or established before cold weather; or sow in early fall, carry plants over in cold frame, and transplant to permanent position in spring.

TABLE 2—WOODY PLANTS

Acer ....A, B, I	Cornus ....G, I	Kerria ....E, G	Quercus ....A, I
Aesculus ....B, I	*Cratægus .....B, I	Kœlreuteria C	
Ailanthus ....B	Cytisus ....F, I		Rhamnus C
Akebia C			Robinia ....B, H
Almond (dbl. fl.)..I	Deutzia ....E	Laburnum .....C, I	Rose ....A, F, I
Alnus C	Diervilla ......E, G	Larix I	
Amelamchier ...C, I		Ligustrum .....B, F	Salix ....G, I
Amorpha I	Euonymus ......G, I	*Liquidambar ..A, B	Sambucus ..C, D, G
Ampelopsis ....F	Elæagnus I	Liriodendron ...B, I	Sassafras ......C, H
	Exochorda .....C, D	Lonicera ......A, B	Sophora .....C, F, I
Barberry ....B			Spiræa ....A, F
Betula ......A, B, I	Fagus ....B, I	Magnolia ....A, F, I	Stuartia ....C, D, F
Bignonia ....F	Forsythia ......E, G	Menispermum ....F	*Styrax ....A, B, E
	*Fraxinus ......B, I	Myrica ....A	Symphoricarpus B, E
Calycanthus ....B, C		Mulberry ......G, I	Symplocus .....C, F
Caragana .. D, H, I	Ginkgo ....B, I		Syringa ..D, E, G, I
Carpinus I	Gleditschia .....B, I	Nemopanthes .....A	
Catalpa .....B, E, I		*Nyssa ....B	Tamarix ....G
Ceanothus .....B, D	Halesia ....B		Taxodium ......C, I
Celtis ....A, G	Hamamelis C		Tilia ....B, I
Cephalanthus ....G	Hickory ....B, I	Ostrya ....C, I	
Cercediphyllum ...E	Hydrangea .....E, F	Oxydendrum C	Ulmus ....A, I
Chestnut ....B, I	Hypericum .....G, H		Vaccinium C
Chinquapin I		Paulownia .. ..C, G	*Viburnum ....B, E
Chionanthus ....C, I	Itea C	Philadelphus .....G	
Cladrastis .....D, H		Phellodendron ....H	Wistaria .....C, F, I
Clethra ....F	Juglans ....B, I	Populus ....A, G	
Colutea ....G	Juneberry ....B	Ptelia ....A, I	Xanthoceras ...C, H

* Seeds often require two years to germinate.

A Seeds sown as soon as ripe; hardy kinds in frames outdoors, tender ones in greenhouse.

B Seeds stratified over winter and sown in spring in nursery row.

C Seeds, spring or fall sown, in frames.

D Layers during summer.

E Soft or semi-mature cuttings in early summer.

F Soft or semi-mature cuttings in winter or spring, in gentle heat.

G Ripe wood cuttings in fall, winter, or spring.

H Root cuttings in spring.

I Named varieties and rare species grafted on seedling or cutting-grown stocks.

TABLE 3—EVERGREENS

Abies ......A, D, E	Cistus ....A, H	Kalmia ....B, D	Pinus ....A, D
Andromeda ....B, F	Cotoneaster ......H	Ledum ....F	Pseudotsuga A, B, E
Azalea ....H	Daphne ....G	Leiophyllum ...C, F	Retinospora ...A, D
Buxus C	Empetrum ....H	Leucothoë ......C, F	Rhododendron .A, D
Calluna ....H	*Ilex ....A, D	Mahonia ....H	Taxus ....A, D
Cedrus ....A, D	*Juniperus ..A, D, H	Picea ....D, E	Thuya ....A, D
Chamæcyparis ....A			

A Sow seeds in spring. Transplant seedlings to nursery rows following spring.

B Sow freshly ripe seeds thinly in peaty-sandy soil, or sphagnum, in pots or pans. Give ample air in cold frame. Plant out seedlings following spring, or, if too small, prick out in flats.

C Sow newly ripe seeds in light, well-drained soil in cold frame.

D Graft named varieties and sparse seeding species during winter on fall potted seedlings. Veneer grafts generally do best.

E Set seedlings of growing tips in sand in shaded frame. Don't disturb from six months to a year.

F Layers pegged down in September will root in a year or less.

G Mature cuttings in fall in well-drained pots of peaty soil in propagating bed. Keep cool during winter. Give gentle heat in spring. Pot rooted plants singly, and grow in mild but close heat till established. Harden off in fall.

H Mature wood cuttings in late summer in sand, in cold frames or cool house.

TABLE 4—VINES

Actinidia	Celastrus	Humulus	Periploca
Akebia	Clematis	Ipomœa	Rose, Climbing
Ampelopsis	Decumaria	Lonicera	Wistaria
Apios	Euonymus	Lycium	
Aristolochia			
Bignonia			

Seeds in late winter or early spring; layers during spring or summer; mature wood cuttings in summer or fall, in mild heat; greenwood cuttings in winter.

Table 5—HARDY PERENNIALS

Acanthus
Achillea
Aconite
Acorus
Actæa
Adonis
Ajuga
Althæa
Alyssum
Amsonia
Anchusa
Anemone
Anthemis
Apios
Aquilegia
Arabis
Arenaria
Armeria
Arnica
Artemisia
Arundo
Asperula
Asphodeline
Aubretia
Auricula

Baptisia
Bellis
Bocconia
Boltonia
Borago

Callirrhöe
Campanula
Caryopteris

Cassia
Catananche
Centaurea
Centranthus
Cerastium
Chelone
Chrysanthemum
Cimicifuga
Clematis
Clintonia
Coreopsis

Delphinium
Dianthus
Dicentra
Dictamnus
Digitalis
Dodecatheon
Doronicum
Dracocephalum

Echinops
Elecampane
Epimedium
Eryngium
Eupatorium

Gaillardia
Galega
Gentiana
Geum
Gynerium
Gypsophila

Hæmodorum
Hedysarum
Hepatica
Heracleum
Hesperis
Heuchera
Hollyhock
Houstonia
Hyssop

Inula

Liatris
Linaria
Lobelia
Lychnis
Lysimachia
Lythrum

Mandragora
Menispermum
Mertensia
Miscanthus

Oenothera

Pentstemon
Phalaris
Phlomis
Phlox
Platycodon
Podophyllum
Polemonium

Polygonatum
Polygonum
Potentilla

Ranunculus
Rheum
Rudbeckia

Salvia
Sanguinaria
Saponaria
Saxifraga
Scabiosa
Shepherdia
Silene
Silphium
Sisyrinchium
Stachys
Staphylea
Statice
Stokesia

Tansy
Thalictrum
Trillium
Trollius

Uvularia

Verbascum
Veronica

Wormwood

Yucca

Sow the above named species (1) outdoors after danger of frost in beds of finely pulverized, light soil, transplant to permanent place when large enough to become established before cold weather; (2) or sow the seed between midsummer and early fall in cold frames, protect over winter, and plant the seedlings in the spring; (3) start the seeds during midwinter in the greenhouse, transplant to small plots, and shift when rooted. In case three, plants kept growing sturdily will usually bloom the first season.

Table 6—BULBS, CORMS AND TUBERS

Agapanthus	A
Allium	B
Alstrœmeria	E
Amaryllis	D
Amorphophallus	D
Anemone	E
Anomatheca	E
Anthericum	E
Apios	E
Astilbe	A
Begonia	A
Boussingaulia	A
Bravoa	B
Caladium	C
Canna	A
Chionodoxa	B
Colchicum	B
Convallaria	E
Crocus	B
Dahlia	A
Dicentra	E
Dioscorea	E
Eranthis	E
Eremurus	E
Erythronium	E
Eucharis	E
Freesia	B
Fritillaria	A
Funkia	A
Galanthus	B
Galtonia	B
Gladiolus	B
Helleborus	A
Hemerocallis	A
Hippeastrum	B
*Hyacinth	
Iris	A, B
Ixia	B
Kniphofia	B
Leucoium	F
Lilium	B
Milla	B
Muscari	B
Narcissus	B
Ornithogalum	B
Oxalis	B
Pæony	E
Polianthes	B
Puschkinia	B
Ranunculus	A
Richardia	C
Scilla	B
Sparaxis	E
Tigridia	E
Trillium	E
Triteleia	D
Tritonia	D
Tulipa	B
Zephyranthes	B

* See 115 for special treatment.

A Seeds. Offsets, tubers, or divisions of old plants early in spring.

B Seeds. Bulbels or offsets fall planted under glass, or spring planted out of doors.

C Tubers, dried or rested. Divide large, healthy ones. Keep pots in moderate night temperature; syringe once or twice daily.

D Seeds. Offsets or divisions at any time.

E Seeds. Division of roots fall or spring.

F Bulbels as soon as possible after foliage matures.

TABLE 7—GREENHOUSE AND HOUSE PLANTS

Abutilon	A	Begonia	A	Fuchsia	A	Polianthes	
Acalypha	B	Bouganvillea	F	Genista	B	Plumbago	B
Acanthus	C	Bouvardia	B, C	Geranium	A	Richardia	C
Achyranthes	A	Caladium	C, G	Hibiscus	A, H	Sanseveriera	E
Agapanthus	B	Calla	C	Hydrangea	A	Smilax	E
Ageratum	A	Canna	C	Jasminum	B, F	Swainsona	A
Allamanda	B	Carnation	A	Lantana	A	Thunbergia	H
Aloysia	B	Chrysanthemum	H	Lobelia	A	Tigridia	D
Alternanthera	A	Clerodendron	A, C, E	Moon-flower	B	Tuberose	D
Alyssum	A	Clevia		Pandanus	B, E	Vallota	D
Amaryllis	D	Cobœa	A	Passiflora	A	Verbena	A
Anthericum	C	Coleus	B	Pelargonium	A	Vinca	C
Antirrhinum	A	Colocasia	G			Zephyranthes	D
Ardisia	A	Dieffenbachia	G				
Asparagus	C	Eucharis	D				
Aspidistra	E						
Aucuba	A						

A Green wood cuttings at any time, rather warm temperature; after rooting pot in friable soil.

B Green wood cuttings, warm temperature; late winter or early spring.

C Root division or root cuttings; autumn or early spring.

D Off-sets or divisions; whenever mature enough to remove.

E Division, crown, or suckers at any time.

F Semi-mature wood cuttings, warm temperature.

G Tubers, dry or resting, moderate temperature; syringed daily at least once.

H Semi-mature wood cuttings, fall, winter or spring. Low temperature.

TABLE 8—FERNS

Acrostichum		Cyathea		Lastrea		*Platycerium	
Adiantum	A	Cyrtonium		Lomaria		Platyloma	
Alsophila		Cystopteris		*Lygodium		*Polypodium	
Anemia		*Davallia		Nephrodium		Polystichum	A
Aspidium		*Dicksonia		*Nephrolepis		Pteris	
Asplenium	A	Doodia		Onychium		Scolopendrium	
Botrychium		Doryopteris		*Osmunda		**Selaginella	
Cheilanthes		Gleichenia					
Civotium		Gymnogramma	A				

* Propagated largely by division.
** Propagated by short cuttings in pots or pans in early spring.

Steam sterilized soil at high temperature to destroy fern enemies.

Soil mixture: Two parts each garden loam and peat (or leaf mold) and one part clean, sharp sand. Use only sterilized (boiled and cooled) water for watering. Buy only best grade spores. Sow in March, July, or October. Use cans 12 inches square and 4 inches deep, or 6-inch ¾ pots, each a third full of drainage (cinders). Press soil firmly in pots or pans. Pass surface half inch through ⅛-inch screen, level, press and water. Wait four hours before dusting spores on surface. Use no more spores for 12-inch pan than will pile on a ¼-inch circle. Have no breeze while sowing. Don't cover with soil. Place shaded sash over frame and keep closed till germination starts, then give air, little at first, more gradually till fronds appear and are hardened enough to have sash removed. Use no water for first two or more weeks. Weed out undesirable plants. When pot surface is covered with little ferns, prick out in clumps of three to six just level with surface of other flats. When clumps have three or four fronds, transplant singly in other pans or flats, and later into 2 or 2¼-inch pots.

A Certain ferns (among them species and varieties of genera marked A in the list) bear detachable buds, bulblets, or plantlets on fronds and pinnæ. These, planted in well-drained seed pans, usually take root in less than two weeks. Others may be divided just before the plants start to grow.

TABLE 9—PALMS

Acanthophœnix Acanthorhiza Acrocomia Archonphœnix Areca Arenga Astrocarpum Attalea *Bactris Bacularia Borassus Brahea Calamus Calyptrogyne *Caryota Ceratolobus Ceroxylon Certostachys Chamædorea Chamærops	Clinostigma *Cocos Corypha Cycas Cyphophœnix Cyphosperma Dictosperma Didymosperma Dion Diplothemium Drymophlœus Dypsis Elæis Erythea Euterpe *Geonoma Hedyscepe Howea Hydriastele	Hyophorbæ Hyphæne Jubæa Kentia Kentiopsis Latania Licuala Linospadix Livistonia Lodoicea Martinezia Maxillminia Nenga Oreodoxa *Phœnix Phytelephas	Pinanga *Pecctocomia Pritchardia Ptychosperma Raphia Rhapidophyllum Rhapis Rhopalostylis Roscheria *Sabal Scheilea Seaforthea Thrinax *Trachycarpus Veitchia Verschaffeltia *Wallichia Washingtonia

* Easily grown from suckers.

Sow seeds thickly, ½-inch deep, in sandy loam in propagating frame in warm greenhouse. Give plenty of heat and moisture. Some species require two or three weeks to germinate, others two months, still others three years. Possibly the sulphuric acid method (47) may shorten these longer times. Keep night temperature 55 to 60 and day 70 to 75. Supply ample water. Prick off in small pots when first leaves are well formed, and shift to larger sizes slowly, but as needed. Use friable compost of rotted sod and stable manure, with peat, leaf mold and sand.

TABLE 10—WATER PLANTS

Acorus .... A Alisma .... B Aponogeton .... B, C Cabomba ...... A, B Caltha .... A, B Cyperus .... A, B Eichhornia .... A, B	Juncus .... A Jussiæa (Jussieua) B Limnanthemum .. B Limnocharis A, B, E Ludwigia .... B Lyriophyllum .... B	Nelumbium A*, B, F Nymphæa ...... B, F Orontium ...... A, B Ouvirandra .... A, B Peltandra ..... A, B Pontederia .... A, B Sagittaria ..... A, B	Saururus .... H Scirpus (Juncus) .. A Trapa .... B Typha .... A, B Victoria .... G Zizania .... B

* Seeds should be cut to admit water.

A Division in spring.

B Newly ripe seeds in pots plunged in water, under glass.

C Off-sets at any time.

D Division after flower.

E Runners, or stolin.

F Cuttings of rhizome (12 inches long), kept under water when out of doors.

G Keep seeds wet from ripening till sown. Place in sandy loam in pots. Immerse 2 inches deep in water never less than 85 degrees, in well-lighted tank, near the glass.

H Sow in moist loam.

TABLE II—ORCHIDS

Acanthephippium A	Broughtonia A	Dendrobium B	Phaius A
Aceras A	Bulbophyllum A	**Disa A	***Phalænopsis B
Ada A	Burlingtonia A	Epidendrum B	***Saccalobium B
Aerides B	Calanthe A	Lælia A	Satyrium A
Aganisia A	*Calopogon	Lycaste A	Sobralia A
Anguloa A	*Calypso	Masdevallia A	Stanhopea A
Anœctochilus A, B	Catasetum A	Maxillaria A	Thunia B
Ansellia A	Cattleya A	Microstylis B	Trichopilia A
Aplectrum A	Cœlogyne A	Miltonia A	Vanda B
Barkeria B	Comparettia A	Odontoglossum A	Vanilla A, B
**Batemannia A	Cymbidium A	Oncidium A	Zygopetalum A
Bletia A, B	Cypripedium A		
Brassia A			

* Offsets usually employed. Difficult to handle.
** Offsets also.
*** Some species form plantlets on old flower stems when pegged down on moss; others form plantlets on the roots.

Seeds. Hand pollination of cultivated orchids is necessary to secure seeds. Choose nearly related genera or species where hybrids are desired, because distantly related ones may not "take to each other," or the offspring may resemble the seed-bearing parent. Select for the seed-bearing parent a plant of vigorous health, free growth and flowering habit, because the offspring usually "take after the mother" in form, but after the "father" in flower color. To pollinate, place one or more ripe pollen masses on the right stigma of the female flower. Seeds require sometimes three to six months, but oftener a year, to ripen. Sow seed as soon as ripe by dusting on surface of pots or baskets in which healthy plants of the same genus are grown. Keep moist with very fine rose till seedlings are started. Spring-sown seed usually sprouts quickest. Some species require a year or more to germinate. When seedlings have two or three leaves, plant in flats, or singly in small pots, in compost suited to the parent, but finer. Should compost become sour, transfer seedlings to other soil.

A Division. Choose none but sturdy plants. Carefully remove soil. Cut plant with keen knife so each piece will have at least one "lead." In some cases the procumbent rhizomes produce only one growth from the pseudo bulb. With these cut part way through the rhizomes two or three pseudo bulbs behind the leaf, in late winter or early spring. Count on one new bud from the base of the bulb next the division. Do not separate till the lead is well established; then sever and pot.

B Cuttings. Choose long-jointed species. In midwinter, just before plants start growth, cut old pseudo bulbs according to joints. Lay pieces on moist moss in warm propagating frame. When young offshoots have started well, pot whole piece and plantlet. Where the rhizomes form roots before cutting, leave such roots on the lower parts of the stems (at least a foot long), discarding the upper part. These stems produce new growths, which may be rooted later.

Table 12—CACTI

Cereus	**A**	**Epiphyllum**		**Opuntia**	**A**	**Phyllocactus**	
						Pilocereus	
Echinocactus	**A**	**Mamillaria**	**A**	**Pelecyphora**	**A**		
Echinopsis	**A**	**Melocactus**		**Pereskia**		**Rhipsalis**	

A Sow seeds in sandy soil in semi-shade till sprouting starts; then expose to sun. Water with care. Seeds give best results particularly with species marked **A**.

B Make cuttings, or make off-sets, with sharp knife. Lay in sun or on dry sand till wounds heal and roots start; then pot in sandy soil and syringe daily, or oftener.

C Graft weak or sprawling kinds on strong or erect species (E.g., **Pereskia aculeapa**, p. **Bleo**, **Cereus Peruvanius** and C. **Tortuosus**). See 329.

INDEX TO PLANT LISTS

The numbers refer to the Plant Lists on the preceding pages.

A

B

C

D

E

Propagation of Vegetables from Seeds

Kinds of Vegetables	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Artichoke, French....	—	E	—	B	B	—	—	—	—	—	—	—
Artichoke, Jerusalem	—	—	—	A	A	—	—	—	—	—	—	—
Asparagus...........	—	—	F	A	—	—	—	—	—	—	—	—
Balm................	—	—	E	B	B	—	—	—	—	—	—	—
Basil...............	—	—	E	B	B	—	—	—	—	—	—	—
Beans, bush.........	G	G	G	A	C	C	C	A	—	—	—	—
Beans, pole and lima	—	—	—	—	A	A	—	—	—	—	—	—
Beets...............	—	—	E	E	A	A	A	A	—	—	—	—
Borecole or kale.....	—	—	—	—	B	B	B	—	—	—	—	—
Broccoli............	—	E	E	B	B	B	—	—	H	H	—	—
Brussels Sprouts.....	—	—	—	—	B	B	—	—	—	—	—	—
Cabbage, all kinds...	—	E	E	B	B	B	—	—	H	H	—	—
Cardoon.............	—	E	E	B	B	B	—	—	—	—	—	—
Carrot..............	G	G	F	A	A	A	A	—	—	—	—	—
Cauliflower..........	G	E	E	B	B	B	—	—	—	—	—	—
Celery and Celeriac...	—	E	E	B	B	B	—	—	—	—	—	—
Chard, Swiss.........	—	—	E	E	A	A	A	A	—	—	—	—
Chervil.............	—	—	C	C	C	—	—	C	C	I	—	—
Chicory.............	—	—	F	A	A	A	—	—	—	—	—	—
Collard.............	—	—	—	—	—	—	A	A	A	—	—	—
Corn, field..........	—	—	—	A	A	A	—	—	—	—	—	—
Corn, pop...........	—	—	—	A	A	A	—	—	—	—	—	—
Corn, salad.........	—	—	F	A	A	A	—	—	H	—	—	—
Corn, sweet.........	—	—	—	C	C	C	C	A	—	—	—	—
Cucumber...........	G	G	G	E	A	A	—	G	G	—	—	—
Dill................	—	—	E	B	B	—	—	—	—	—	—	—
Eggplant............	—	G	E	B	B	B	—	—	—	—	—	—
Endive..............	—	—	—	B	B	B	B	—	—	—	—	—
Fennel..............	—	—	A	A	A	—	—	A	I	—	—	—
Kohl Rabi...........	G	G	E	B	B	B	B	—	—	—	—	—
Leek................	—	E	E	B	B	B	—	—	—	—	—	—
Lettuce.............	G	E	E	B	C	C	C	A	J	J	H	—
Mangel..............	—	—	F	A	A	A	—	—	—	—	—	—
Marjoram...........	H	H	H	E	E	J	G	—	—	—	—	—
Martynia............	—	—	—	—	A	A	—	—	—	—	—	—
Melon, musk........	G	G	G	E	A	A	J	G	—	—	—	—
Melon, water	G	G	G	E	A	A	J	G	—	—	—	—
Mushroom...........	K	K	L	—	—	—	—	L	K	K	K	K
Mustard............	M	M	M	A	A	A	—	A	A	M	M	M
Nasturtium..........	—	—	—	A	A	—	—	—	—	—	—	—
Okra................	—	—	E	E	C	C	C	—	—	—	—	—
Onion...............	—	E	E	B	B	—	—	—	—	—	—	—
Parsley.............	G	G	E	A	A	A	A	—	—	—	—	—
Parsnip.............	—	—	F	A	A	A	—	—	—	—	—	—
Pea	—	—	F	C	C	C	C	A	—	A	—	—
Pepper..............	—	E	E	E	B	—	—	—	—	—	—	—
Peppergrass..........	M	M	M	M	A	A	—	—	M	M	M	M
Potato..............	—	—	—	A	A	—	—	—	—	—	—	—
Pumpkin............	—	—	—	E	A	A	—	—	—	—	—	—
Radish..............	M	M	M	D	D	D	—	—	J	J	—	—
Radish, winter.......	—	—	—	—	—	—	A	A	—	—	—	—
Rutabaga..	—	—	—	—	—	—	—	A	A	—	—	—
Sage	—	—	E	B	B	—	—	—	—	—	—	—
Salsify.............	—	—	F	A	—	—	—	A	A	—	—	—
Savory..............	—	—	E	B	B	—	—	—	—	—	—	—
Scorzonera..........	—	—	F	A	A	A	—	—	—	—	—	—
Sea kale............	—	—	F	A	A	A	—	—	—	—	—	—
Skirret.............	—	E	E	B	B	—	—	I	I	H	—	—
Spinach.............	—	—	F	A	A	—	—	—	C	I	—	—

Propagation of Vegetables from Seeds

Kinds of Vegetables	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Squash	—	—	E	E	A	A	—	—	—	—	—	—
Thyme	—		E	B	B	—	—	—	—	—	—	—
Tomato	G	G	E	B	B	B	—	G	G	G	—	—
Turnip	—	A	A	—	—	—	A	A	—	—	—	—
Witloof	—	—	A	A	A	—	—	—	—	—	—	—

KEY TO VEGETABLE PROPAGATION TABLE

A. Sow in open ground; thin plants to proper distances.
B. Sow in garden seed bed and transplant to permanent quarters.
C. Sow twice in open ground during month.
D. Sow thrice in open ground during month.
E. Start in hotbed; plant in open when weather and soil favor.
F. Sow outdoors as soon as open ground can be worked.
G. Grow only in hotbed or greenhouse.
H. Sow in coldframe; protect winter; plant out in spring.
I. Sow in open ground; protect with litter during winter.
J. Plant in frame; cover with sash and straw mats during cold weather.
K. Plant in cellar, barn or under benches in greenhouse.
L. Plant out-doors in prepared beds.
M. Sow weekly in greenhouse or frame for succession.

Note 1. For last planting of bean, sweet corn, kohl rabi, pea, radish, and tomato use quickest maturing varieties.

Note 2. Late sowings of salsify and scorzonera may remain unprotected in ground over winter. Roots will be larger following fall than spring-sown ones.

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